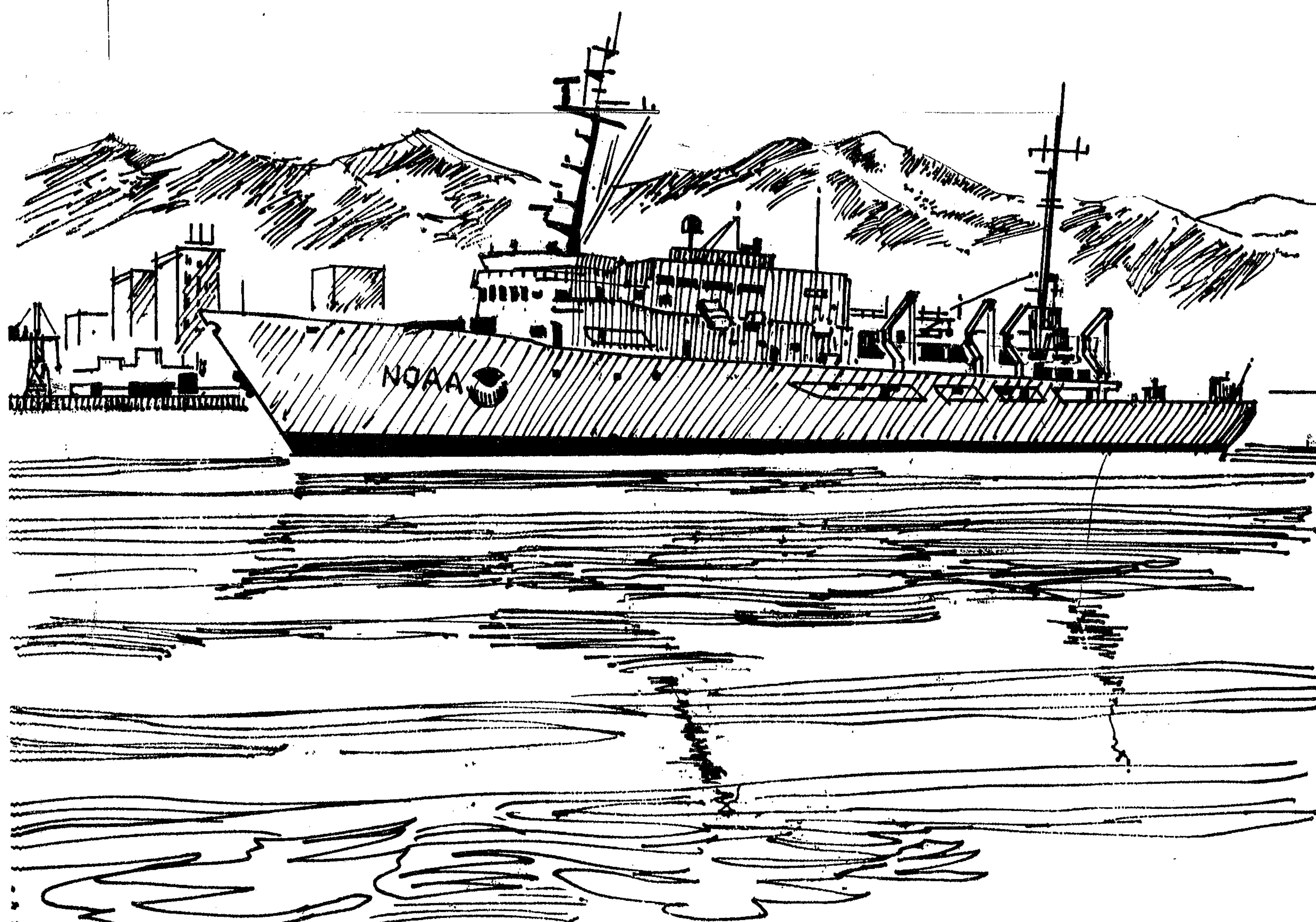
US Army Corps
of Engineers
Alaska District

Deep Draft Navigation Reconnaissance Report

Cook Inlet, Alaska



April 1993

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, ALASKA
P.O. BOX 898
ANCHORAGE, ALASKA 99506-0898

COOK INLET DEEP DRAFT NAVIGATION RECONNAISSANCE REPORT

April 1993

ACKNOWLEDGMENTS

The investigations summarized in this report were conducted primarily by the staff of the Alaska District, U.S. Army Corps of Engineers, in Anchorage, Alaska. The principal investigator was Dr. Orson P. Smith of the Project Formulation Section in the Civil Works Branch, Engineering Division of the Alaska District.

An extensive technical literature search was performed largely through the efforts of Mr. James B. Sauceda of the Soils and Geology Section, Geotechnical Branch, Engineering Division of the Alaska District, and Mr. Tim Welp of the U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center (CERC), Vicksburg, Mississippi, who was assigned to the Alaska District on temporary duty.

Economic analyses were performed by Mr. Bob Pfeiffer of the Corps' Little Rock District, assigned to the Alaska District on temporary duty. Further economic analysis was performed by Mr. Richard Geiger of the Economics Section and Mr. Keith Hofseth, Chief of the Economics Section, Civil Works Branch.

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SUMMARY

This study was conducted in response to similar resolutions of the U.S. Senate and House of Representatives, dated April 27, 1970, and December 2, 1970, requesting Corps of Engineers study of deep draft navigation improvements for Southcentral Alaska. This report focuses on Cook Inlet, an estuary extending approximately 200 miles southward from the city of Anchorage at the confluence of Knik and Turnagain Arms to the southern tip of the Kenai Peninsula. Deep draft vessels call at oil terminals along the Kenai Peninsula, but the majority of deep draft ships in Cook Inlet are approaching or departing from the Port of Anchorage on Knik Arm at the inlet's northern end.

Deep draft vessels must wait for higher tidal stages before crossing the shoals in Knik Arm. Tidal ranges in Knik Arm exceed 30 feet, the highest in the United States and second highest in all of the Americas. The shoals of primary concern are Knik Arm Shoal, 6 miles from the Port of Anchorage, and Fire Island Shoal, 12 miles from the port. Fire Island Shoal was a great concern in years past. The crest of this shoal has been migrating southward since 1941, and pilots recently have begun guiding ships north of the crest where depths of 48 feet are available at low tide across a wide natural channel.

Knik Arm Shoal, a mound-like feature, appears to be a stable glacial deposit of gravel and boulders overwashed by sand. Its controlling depth at low tide is 25 feet. Waters in Knik Arm are highly turbid; the Corps of Engineers presently removes about 225,000 cubic yards of silt from the maneuvering area at the Port of Anchorage. The silt in suspension does not settle near Knik Arm Shoal because of consistently strong currents, which can exceed 4 knots. A 1992 survey by the National Oceanic and Atmospheric Administration (NOAA) indicates that the shape of Knik Arm Shoal has changed little since a similar survey 10 years ago. North Point Shoal, a sandy shoal immediately north of Knik Arm Shoal, shows dramatic movement, in one place retreating about one-half mile and in another advancing across Knik Arm for about one-half mile. Some minor advance across the inlet was noted at Woronzof Shoal, immediately south of Knik Arm Shoal.

A computer simulation of ships' journeys in Cook Inlet was developed. Simulated arrivals at the Port of Anchorage agreed with records of actual arrivals provided by port officials. The simulations reveal that containerships regularly serving Anchorage are delayed 3.8 to 5.9 hours per passage because of Knik Arm Shoal. An excavated channel 35 feet deep at low tide would reduce this delay by 2.5 to 3.1 hours per passage.

The channel would be aligned along the southern flank of Knik Arm, following the present Fire Island navigation range (charted shipping route). Initial excavation would be to 39 feet at low tide, 4 feet below the 35-foot design depth, to allow for bottom irregularities and to decrease the frequency of maintenance dredging. This dredging is

expected to be required no more than every other year. A channel width of 800 feet allows for safe navigation in the worst of icy winter conditions. An additional 100 feet on each side would be excavated so that maintenance dredging would be necessary no more than every other year. The initial excavation quantity is estimated as 353,000 cubic yards. The cost of the initial excavation is estimated as $2.296 million, of which a local sponsor's share would be $803,600 (35 percent). Maintenance dredging quantities are estimated to be 80,000 cubic yards in years 2 and 4 at a cost of $433,600, followed by 60,000 cubic yards at a cost of $325,200 every other year thereafter.

The average annual transportation savings achieved by the proposed channel improvement would exceed the average annual costs by a ratio of 2.3:1. No objectionable environmental impacts appear likely. The Municipality of Anchorage has expressed interest in acting as local sponsor and is legally and financially capable of doing so. A cost-shared feasibility study is recommended.

COOK INLET DEEP DRAFT NAVIGATION
RECONNAISSANCE REPORT

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APPENDIXES

DOCUMENTS PUBLISHED SEPARATELY

Annotated Bibliography

1992 Field Data Collection

Draft Plan of Feasibility Study

Draft Feasibility Study Cost-Sharing Agreement

March 25, 1993 - MAIN REPORT FILE NAMES:
K:\COOKINLT\REPORT\ (all)
FRONTMTR.CR
PARTI.TXT
PARTII.TXT
PARTIII.TXT
PARTIV.TXT
PARTV.TXT
PARTVI.TXT
PARTVII.TXT
REFS.TXT

CONVERSION FACTORS, ENGLISH TO SI (METRIC) UNITS OF MEASUREMENT

Units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To obtain
cubic yards	0.7646	cubic meters
cubic yards per year	0.7646	cubic meters per year
Fahrenheit degrees	5/9	Celsius degrees*
feet	0.3048	meters
feet per second	0.3048	meters per second
inches	2.54	centimeters
knots (international)	0.5144444	meters per second
miles (U.S. statute)	1.6093	kilometers
miles (nautical)	1.8520	kilometers
miles per hour	1.6093	kilometers per hour
pounds (mass)	0.4536	kilograms
yards	0.9144	meters

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: C = (5/9)(F - 32).

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND TECHNICAL TERMS

ADCED = Alaska Department of Commerce and Economic Development
ADCP = acoustic Doppler current profiler, an instrument for measuring the speed of water currents
ADOT&PF = Alaska Department of Transportation and Public Facilities
AEC = Alaska Engineering Commission (historical)
AIDEA = Alaska Industrial Development and Export Authority
AOML = Atlantic Oceanographic and Meteorological Laboratory (of the Corps of Engineers)
CTD = conductivity-temperature-depth sensor, a device that measures these three characteristics of water
DGPS = Differential Global Positioning System, an improved form of GPS (see below)
dwt = deadweight ton(s)
ECDIS = electronic chart display
ER = Engineering Regulation
ft = foot, feet
ft^3/s = cubic feet per second
GPS = Global Positioning System, a system of navigation using electronic distance measurements to satellites in orbit
m = meter(s)
mg/l = milligrams per liter
mi = mile(s)
MLLW = mean lower low water
mm = millimeter(s)
NED = National Economic Development; a measure of change in the economic value of the national output of goods and services resulting from a project
NEPA = National Environmental Policy Act (of 1969)
nmi = nautical mile(s)
NOAA = National Oceanic and Atmospheric Administration
OBS = optical backscatter, a method of measuring suspended sediment concentration in water
POL = petroleum, oils, and lubricants
Ro/Ro = roll-on, roll-off; a type of freight container that can be rolled on and off a ship
TOTE = Totem Ocean Trailer Express, a freight company

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Field data collection and analysis were accomplished with the assistance of CERC in Vicksburg, Mississippi, and the NOAA Atlantic Oceanographic and Meteorological Laboratory, Miami, Florida. Investigators from CERC included Dr. Nicholas Kraus and

Mr. Michael Tubman. The CERC subcontracted the assistance of RD Instruments, Inc. (RDI) and SonTek, Inc., both of San Diego, California. Dr. Blair Brumley and Mr. Craig Huhta of RDI performed acoustic field data collection. Mr. Atle Lohrmann of SonTek also performed acoustic field data collection and analysis of the RDI data. Investigators from AOML included Mr. Paul Dammann and Mr. Jeff Bufkin; both collected field data with an instrument provided by AOML. Mr. Dammann analyzed the AOML data.

Water samples from Cook Inlet were analyzed by Dr. Sathy Naidu and Dr. Bruce Finney under contract with the University of Alaska Fairbanks, Institute of Marine Science.

Ms. Carolyn Rinehart of Project Formulation Section was the main editor of this report and wrote appendix A. Ms. Diane Walters of Environmental Resources Section edited appendix D and wrote the portions of the main report on history, demography, and the ports of Southcentral Alaska.

These investigations were conducted under the direction of Mr. Claude V. Vining, Chief, Engineering Division; Mr. Kenneth E. Hitch, Chief, Civil Works Branch; Mr. Carl E. Borash, Chief, Project Formulation Section; Mr. Carl Stormer, Chief, Hydraulics and Hydrology Section; Mr. Keith Hofseth, Chief, Economics Section; and Mr. Guy R. McConnell, Chief, Environmental Resources Section.

Commander and District Engineer of the Alaska District during this study was Colonel John W. Pierce, Corps of Engineers.

COOK INLET DEEP DRAFT NAVIGATION RECONNAISSANCE REPORT

1. INTRODUCTION

1.1 Study Authority

The efforts summarized in this report were conducted in partial response to similar resolutions of the Committees on Public Works of the United States Senate and House of Representatives, adopted April 27, 1970, and December 2, 1970, respectively. The House committee resolution read:

> *Resolved by the Committee on Public Works of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors is hereby requested to review the reports of the Chief of Engineers on Copper River and Gulf Coast, Alaska, published as House Document Numbered 182, Eighty-third Congress, and on Cook Inlet and Tributaries, Alaska, published as House Document Numbered 34, Eighty-fifth Congress, and other pertinent reports, with a view to developing a comprehensive plan of improvement in the interest of deep-draft navigation for the Southcentral Region of Alaska.*

1.2 Federal Interest

The Federal Government may participate in constructing public works within the limits of legislated authority. The Federal interest in public works for navigation is derived from the commerce clause of the U.S. Constitution and is limited to the navigable waters of the United States. Federal navigation improvements in or on those waters must be justified as being in the general public interest and must be open to the use of all on equal terms. Improvements such as channels, jetties, breakwaters, locks, dams, maneuvering basins, turning basins, passing channels, and ice control structures may be eligible for Federal participation as general navigation features of harbor or waterway projects. Special navigation works may also be in the Federal interest, such as removal of wrecks or obstructions, snagging and clearing for navigation, or drift and debris removal. On the other hand, facilities to accommodate vessels or load and unload cargo and passengers, such as docks or floats, are solely the responsibility of local interests. This is so even though the facilities may be required to achieve the benefits of the Federal project. Aids to navigation, such as buoys, ranges, lights, or channel markers, are usually required for safe navigation and to achieve the project benefits. These aids are the responsibility of the U.S. Coast Guard.

1.3 Reconnaissance-Level Objectives

The reconnaissance phase of a Corps of Engineers navigation study is meant to identify navigation problems with a solution in the Federal (as opposed to strictly local) interest, as defined above. A reconnaissance report may recommend further studies if at least one problem with a Federal interest is identified, and at least one alternative solution to this problem appears economically feasible with acceptable environmental impacts. The primary goal of the reconnaissance phase is to establish whether further studies by the Federal Government are warranted. Secondary goals, if further studies are recommended, are to identify a local sponsor for these efforts, to prepare a plan of study for the subsequent feasibility phase, and to execute a Feasibility Study Cost-sharing Agreement with the local sponsor. Reconnaissance studies are completed at full Federal cost in 12 to 18 months.

1.4 Federal Policies and Procedures

The Corps of Engineers must follow administrative policies expressed in various Engineering Regulations (ER's) and other Department of the Army memoranda. The most pertinent of these regulations is ER 1105-2-100, "Guidance for Conducting Civil Works Planning Studies." This regulation summarizes and interprets relevant statutes, congressional authorities, executive directives, and other regulations regarding studies of this type and the criteria that must be applied in them.

Prospective projects must be evaluated for their economic feasibility and environmental acceptability as well as for their engineering soundness. The Water Resource Council's publication *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* is used in these evaluations.

Economic feasibility is determined by evaluating the National Economic Development (NED) benefits of the project alternatives. Chapter II of the *Principles and Guidelines*, "National Economic Development Benefit Evaluation Procedures," is used for this purpose. Economic feasibility is established if, within these guidelines, the NED benefits achieved by a solution fully offset the long-term costs of its implementation.

Environmental evaluation of proposed navigation improvements must follow Chapter III of the *Principles and Guidelines*, "Environmental Quality (EQ) Procedures," as well as other Federal, State, and local statutes and regulations. Requirements of the National Environmental Policy Act of 1969 (NEPA), as amended, prevail in these considerations. The reconnaissance study does not recommend implementation of a specific plan; therefore, the alternatives are, in practice, evaluated in this phase with a view toward predicting grossly objectionable impacts that appear likely. The clear likelihood of such an impact from a particular plan may be grounds to eliminate that solution from further consideration. Environmental recommendations in the reconnaissance phase commonly focus on delineating further studies required in the feasibility phase to predict the environmental effects of the alternatives that will be considered.

The goal of completing the reconnaissance phase in 12 to 18 months places a practical constraint on the scope of a reconnaissance study. Likewise, a finite budget, allocated for expenditure within specific fiscal calendar limits, constrains the scope of reconnaissance phase activities.

1.5 Geographical Scope of Study

This study was initiated as a review of regional deep draft navigation problems in Cook Inlet; therefore, the geographical scope for problem identification purposes encloses all of the waters and shoreline of Cook Inlet. The study was also intended to conceive and evaluate alternative solutions to navigation problems identified in this region. The economic considerations necessary to evaluate prospective solutions to Cook Inlet navigation problems include alternate shipping routes through certain ports outside Cook Inlet. The ports of Seward, Whittier, and Valdez, Alaska, via railroad and highway links, serve the same hinterland regions as Cook Inlet ports. The geographical scope for economic considerations therefore includes all final destinations or points of cargo origin in Alaska which may be served by Cook Inlet ports or these alternate routes. The Port of Anchorage is a transshipment center for goods transported by road, rail, and air to and from points throughout the State. The geographical scope for economic considerations thus includes nearly all of Alaska. Ports of origin for imports to Alaska and destination ports for exports lie in the Pacific Northwest, Japan, and Korea. Shipping routes and distances to these ports from the Alaskan ports designated above are determined as a part of the economic analysis included in this study.

1.6 Coordination With Public and Private Interests

A series of coordination meetings was organized at the beginning of this study to discuss the progress of the study with representatives of Federal, State, borough, city, and private maritime interests of the Cook Inlet region. These meetings are summarized in appendix A. At the first meeting, it became apparent that a number of public and private initiatives were recently completed, under way, or about to begin, all of which bore directly on Cook Inlet navigation problems. These included:

a. A navigability study of the approaches to the Port of Anchorage by the Municipality of Anchorage (completed July 1990);

b. A feasibility study of port development on Fire Island by Commonwealth North (completed March 1991);

c. A review of the aids-to-navigation system in upper Cook Inlet by the U.S. Coast Guard (completed September 1991);

d. A feasibility study of port development on Fire Island by the Alaska Industrial Development and Export Authority (completed March 1992);

e. A hydrographic survey of upper Cook Inlet by the National Oceanic and Atmospheric Administration (NOAA, field measurements completed August 1992);

f. A regional port development study by the Alaska Department of Commerce and Economic Development (ADCED, completed January 1993);

g. An ongoing series of plans and designs by the Matanuska-Susitna Borough for a port on Point MacKenzie ("Port MacKenzie," across Knik Arm from Anchorage) for export of timber products and coal; and

h. Ongoing initiatives by the Port of Anchorage (operated by the Municipality of Anchorage) to improve the efficiency of truck and rail access to the port and to expand the port to the north for export of timber products, coal, and other bulk cargo.

Significant opportunities for collaboration between agencies appeared possible, particularly in the cases of the ADCED study and the NOAA survey. Discussions with the ADCED project manager revealed that the ADCED study required economic baseline information which would serve the needs of the Corps study. Corps economists offered suggestions to the ADCED for the scope of contract services to gather economic data for its regional port development study. The suggested scope provisions followed Corps guidance on economic analysis for deep draft navigation feasibility studies. The provisions were generally accepted by the ADCED and incorporated into the study's scope of work. The Corps used some of the resulting data for this report.

The hydrographic survey planned by NOAA presented another opportunity to gather valuable information cooperatively. The Seattle, Washington, and Rockville, Maryland, offices of NOAA were approached about providing limited support for Corps measurements at sea during the NOAA field work scheduled for Cook Inlet in the summer of 1992. The Corps, in turn, offered shoreside support for the NOAA ship *Rainier* during her Cook Inlet visit. Both aspects of this proposal came to pass. Arrangements were made for Corps specialists from the Waterways Experiment Station (Vicksburg, Mississippi), NOAA specialists from the Atlantic Oceanographic and Meteorological Laboratory (AOML, Miami, Florida) to bring acoustic devices for measuring profiles of water velocity and suspended sediment concentrations, and other devices for measuring water properties. The NOAA survey plan was modified to include support for these measurements in July 1992. The NOAA survey plan was further modified at the request of the Matanuska-Susitna Borough to include additional hydrographic and side-scan sonar measurements near the proposed Port MacKenzie project. The measurements were successfully accomplished. More than 400 megabytes of digital data were recorded, revealing details of upper Cook Inlet dynamics never before seen. The *Rainier* provided the Corps with all of the 1992 hydrographic data and 120 samples of seabed material collected all across the survey area. The NOAA Pacific Marine Center (Seattle) and Rockville offices subsequently helped reduce and interpret the hydrographic data provided by the *Rainier*.

2. COOK INLET AND SOUTHCENTRAL ALASKA

2.1 Physical Setting

2.1.1 Geography. Cook Inlet is a large estuary in the south central coast of Alaska. It is included in the sociopolitical region known as "Southcentral Alaska," centered on Anchorage, Alaska's largest city. The inlet is bordered on three sides by rugged mountains, tidal flats, marshlands, and rolling lowlands. Figure 2-1 shows the inlet and the geologic features that surround it. Approximately 200 miles long, the inlet extends from the Knik and Turnagain Arms in the north to the southern tip of the Kenai Peninsula. The inlet includes four major bays: Knik and Turnagain (commonly known as Arms), and Kachemak and Kamishak Bays. Kamishak Bay, the widest, is located in the southwest end of the inlet. It is nearly as wide as it is long, with dimensions close to 25 miles. Knik and Turnagain Arms and Kachemak Bay are narrow, having widths generally less than 5 miles. Both Knik and Turnagain Arms, near Anchorage, are approximately 40 miles long. Kachemak Bay, in the southeast end of the inlet, is about 35 miles long.

Cook Inlet is oriented northeast by southwest and is bounded on the west by the volcanically active Aleutian Mountains, on the northeast by the Alaskan Range, on the northwest by the Talkeetna Mountains, and on the east by the Chugach and Kenai Mountains. It is bordered by extensive tidelands, which give rise to the piedmont plains and the Kenai and Susitna lowlands. The Kenai Lowlands extend 30 to 40 miles from Cook Inlet to the base of the Kenai Mountains. The Susitna lowlands lie at the head of the inlet, between the Talkeetna Mountains and the Alaska Range. On the west side of the inlet, the piedmont plains extend westward to the base of the Alaska Range. The East and West Forelands extend toward each other, creating a narrow area that can be used to divide the inlet geographically into upper and lower regions. The inlet's width

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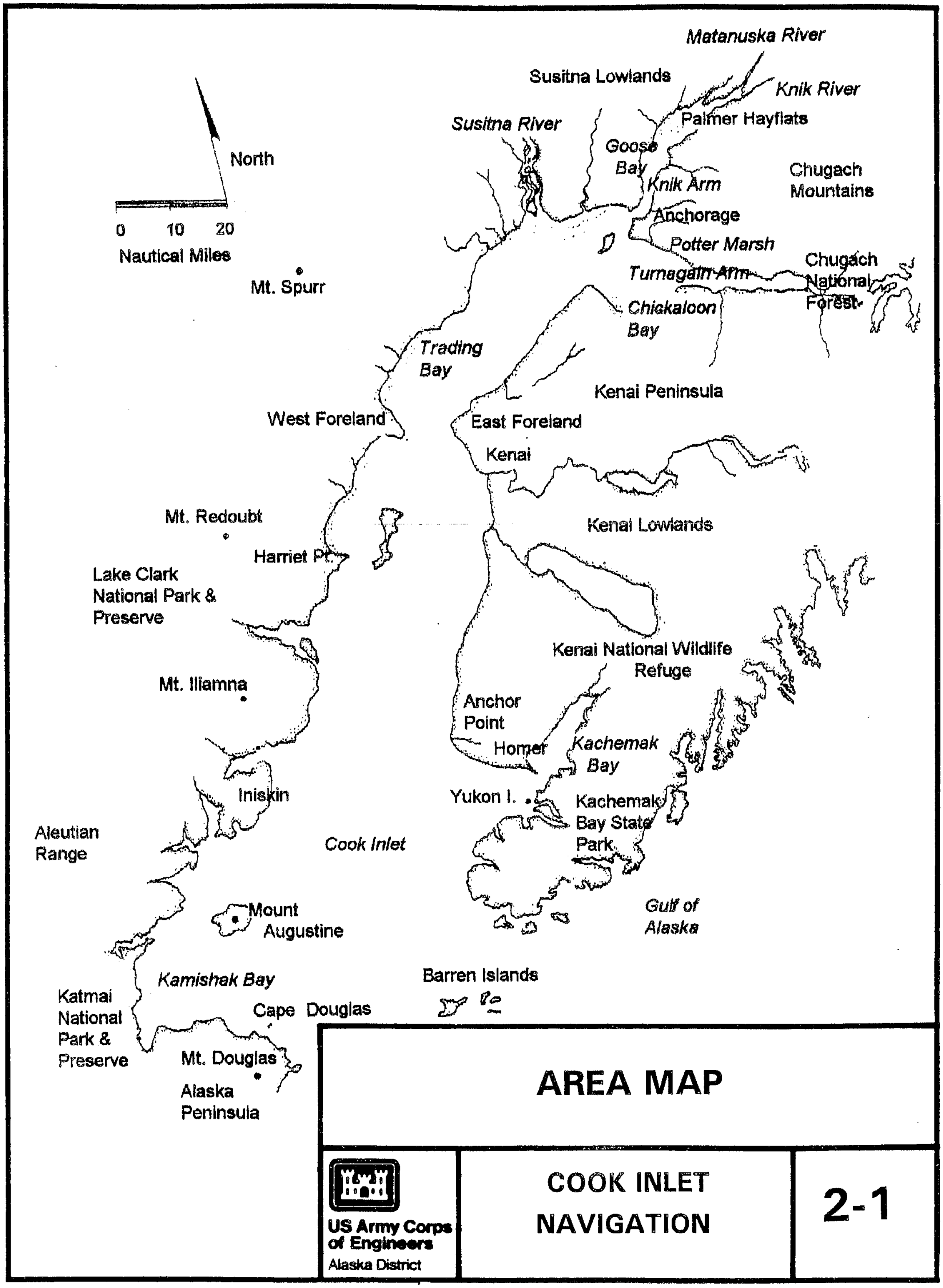


AREA MAP

US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

2-1

increases from just over 20 miles in the north to more than 50 miles in the southern portion.

The shores of Cook Inlet are home to nearly half of Alaska's population. Anchorage, the State's largest city and center of commerce, transportation, recreation, and industry, is located at the inlet's northeast end, between Knik and Turnagain Arms. The Cook Inlet region encompasses a wealth of natural resources, wildlife, and scenery. Lake Clark and Katmai National Parks and Preserves, the Kenai National Wildlife Refuge, Kachemak Bay State Park, and the Chugach National Forest surround the inlet. The State of Alaska owns the submerged lands within 3 miles of the Cook Inlet coast, as well as the intertidal lands (the area between the lines of mean high and mean low tide). The Federal Government has an interest in the navigable waters of Cook Inlet.

Numerous freshwater rivers mix with and dilute incoming Gulf of Alaska sea water, contributing valuable nutrients as they deliver large amounts of sediment to Cook Inlet. The majority of fresh water enters the inlet from three rivers at its northern end. These three rivers, the Matanuska, Susitna, and Knik, contribute nearly 70 percent of the fresh water discharged annually into the inlet (Gatto 1976, 17). In addition, these and other glacier-fed rivers throughout the inlet basin contribute millions of tons of sediment annually to the inlet.

2.1.2 Climate. The Cook Inlet area is in a transition zone between Alaska's maritime and interior climates. The lower inlet has a more maritime climate, with cooler summers and milder winters than in the upper reaches of the inlet. A comparison of temperatures between two cities located at opposite ends of the inlet demonstrates the differing climates. Anchorage, at the head of the inlet, experiences an average winter temperature of 15 °F and a summer average of 55 °F. Homer, near the southern end of the inlet, has averages of 20 °F in winter and 50 °F in the summer.

The maritime climate causes an increase in the total annual precipitation toward the mouth of the inlet. Anchorage, located at the north end of the inlet, receives an average of only 14 inches of precipitation annually. Kenai, midway up the east side, receives 19 inches. Homer, near the southern end, receives 22 inches, while Iniskin, directly across the inlet from Homer, receives 73 inches (Gatto 1976, 20).

The lower part of the inlet receives more winter precipitation in the form of rain and less as snowfall than the upper portion. However, the upper portion of the inlet receives slightly more precipitation in the summer. Fifty percent of the annual precipitation in the basin falls between July and October. The driest period of the year is typically between January and May. In addition, the mountains surrounding the inlet basin greatly affect the local weather. Total annual precipitation is reduced in the inlet by the Chugach and Kenai Mountains, which block the moisture-laden air arriving from the Gulf of Alaska. The mountain ranges on the east and west sides of the inlet funnel winds from the north and south. As a result, winds from the north prevail in the fall, winter, and spring, and southerly winds prevail in the summer throughout the basin. Highest windspeeds occur in the late autumn and winter months.

2.1.3 Geology. The current geologic configuration of Cook Inlet was created by plate movement in the earth's crust (tectonism), deposition of sediment, and glaciation. These geologic processes are discussed below.

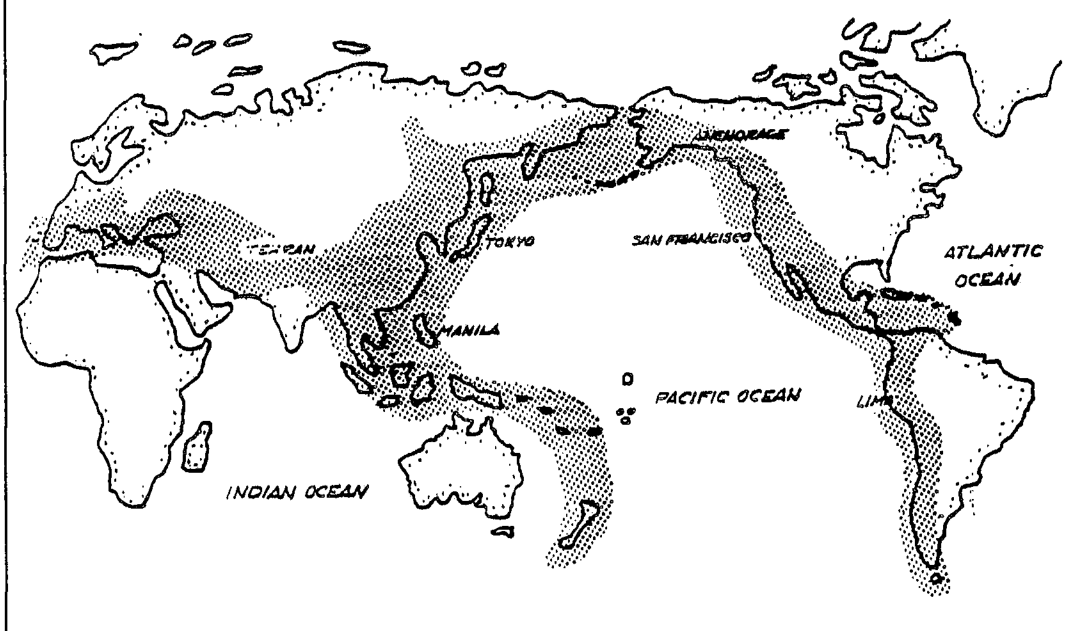
Tectonism, or plate movement, is responsible for creating the basin and mountain ranges, active volcanoes, and earthquakes common to the area. Cook Inlet is an elongated depression of the earth's crust between two parallel faults. In geologic terms, this is referred to as a graben. The basin was created by the folding of the earth's crust that occurred during the Tertiary period, which began approximately 70 million years ago. The inlet lies between the Chugach, Bruin Bay, and Castle Mountain Faults. The mountain ranges, including the volcanically active Aleutian Range, are the result of

Pacific plate subduction. For example, the abrupt faces of the Chugach and Kenai Mountains are attributed to faulting.

Volcanism is also produced by plate subduction. Along the coasts of British Columbia and Alaska, the Pacific and North American plates produce a strike-slip fault. The Pacific plate in Southcentral Alaska is subducting under the North American plate. Five volcanoes border Cook Inlet on the west side, four of which have been active in historic time. These Aleutian Range volcanoes, from the south, are Douglas, Augustine, Iliamna, Redoubt, and Spurr. These volcanoes are classified geologically as andesitic and erupt more violently than the basaltic intrabasin volcanoes of the Pacific plate.

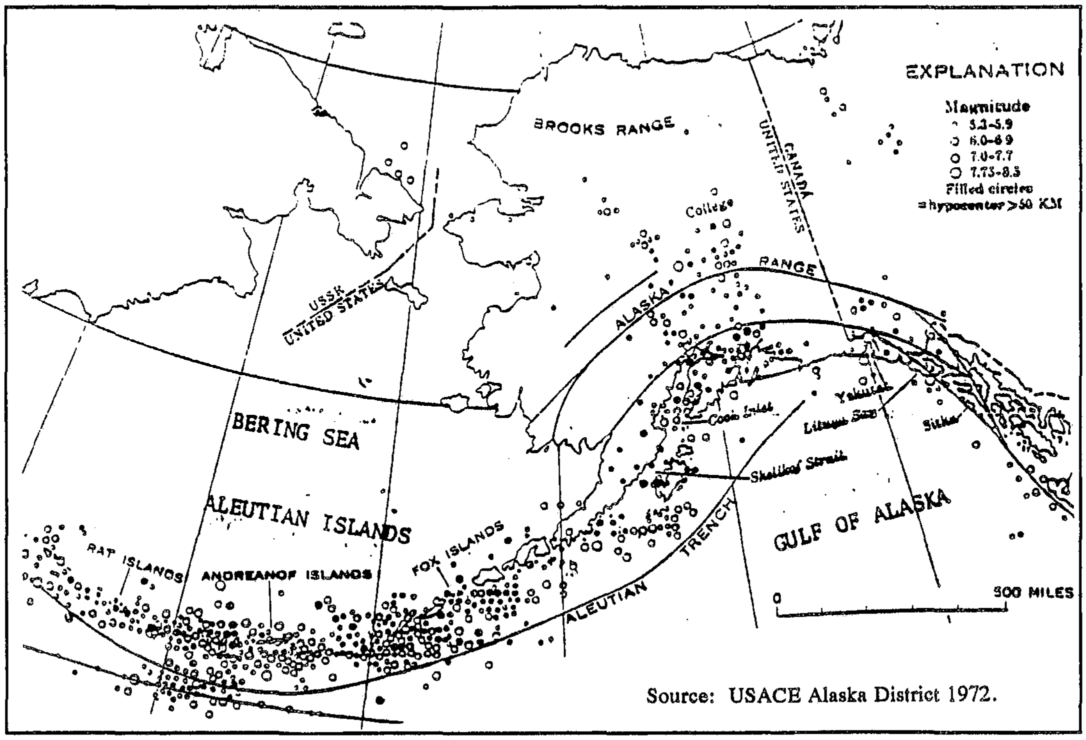
Southern Alaska and the Aleutian chain constitute one of the world's most active seismic zones. The Alaska seismic zone is a part of the vast belt of seismic activity, or "ring of fire," that circumscribes the entire Pacific Ocean Basin (figure 2-2). Between 1899 and 1965, nine Alaska earthquakes equaled or exceeded 8 on the Richter scale and more than 60 equaled or exceeded 7. Almost 7 percent of the earthquake energy released annually in the world originates in the Alaska seismic zone (U.S. Army Corps of Engineers [USACE] Alaska District 1972, II-5). The Cook Inlet region is included in seismic risk zone 4, defined as areas susceptible to earthquakes with magnitudes 6.0 to 8.8 and where major structural damage will occur. Figure 2-3 shows the epicenters of major Alaska earthquakes between 1898 and 1961.

Figure 2-3 does not, however, show the epicenter of the great earthquake which occurred on Good Friday, March 27, 1964. At 5:36 p.m. Alaska Standard Time, an earthquake centered approximately 70 miles west of Anchorage violently rocked Southcentral Alaska for nearly 5 minutes. Just after it occurred, the earthquake was estimated as having a magnitude of 8.5 on the Richter scale. Today's estimates put the magnitude at greater than 9.0. The energy released by the Good Friday earthquake was half again as much as the magnitude-8.3 earthquake which devastated San Francisco in 1906 (Wilson and



Source: USACE Alaska District 1972.

FIGURE 2-2.--Earthquake belts of the world. These belts coincide with the earth's orogenic zones and contain most of the earth's active volcanoes.



Source: USACE Alaska District 1972.

FIGURE 2-3.--Epicenters of major Alaskan earthquakes, 1898-1961.

Torum 1968, 1). The Alaska earthquake caused uplift and subsidence zones that affected areas in and around Cook Inlet. Figure 2-4 shows the locations of subsidence and uplift created by the Good Friday earthquake.

In addition to subsidence and uplift, substantial horizontal movement of the land was documented. An axis along which the land did not sustain any substantial horizontal movement lies roughly in line with Knik Arm in upper Cook Inlet. Land to the north of this axis moved to the northwest, while land south of the axis moved to the south-southeast. Figure 2-5 shows the direction and magnitude of the horizontal land displacements caused by the 1964 earthquake.

These massive earth movements generated a train of tsunami waves which surged across the Pacific Ocean, causing damage as far south as California. In addition, landslides and submarine slumping of unstable glacial deltas created waves which caused localized damage along Alaska's coastline. Areas in the direct path of the tsunami, such as Seward and Kodiak, suffered heavy damages. Tsunami waves reached initial heights of up to 60 feet. Cook Inlet, on the other hand, saw relatively minor tsunami activity. Virtually none was reported in the upper inlet. The main tsunami lost a great deal of energy to reflection, refraction, and diffraction as it entered the mouth of Cook Inlet. As it moved up the inlet, the wave also lost energy to friction and to the powerful ebb currents of the outgoing spring tide (Wilson and Torum 1968, 356).

In addition to being seismically and volcanically active, the Cook Inlet region contains one of the thickest sedimentary basins on earth. Layers of sediment dating back 65 million years exceed 30,000 feet in places (Anthony and Tunley 1976, 156). Sediment was deposited on the ocean bottom in layers. Conglomerates, sandstones, siltstones, limestone, chert, volcanics, and clastics make up the sedimentary rocks of the Cook Inlet basin.

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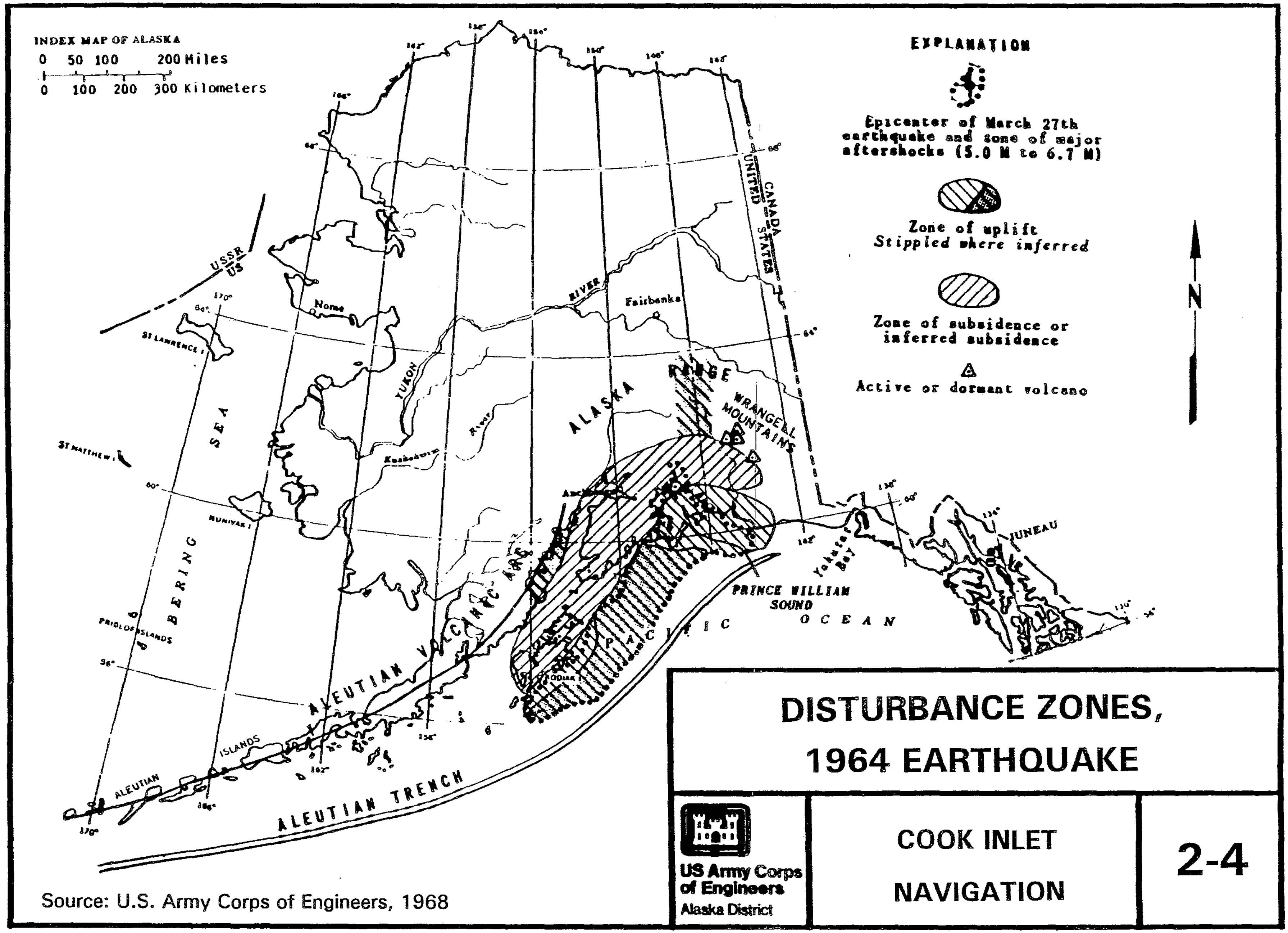

Source: U.S. Army Corps of Engineers, 1968

DISTURBANCE ZONES, 1964 EARTHQUAKE

US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

2-4

Source: U.S. Army Corps of Engineers, 1968 | Alaska District

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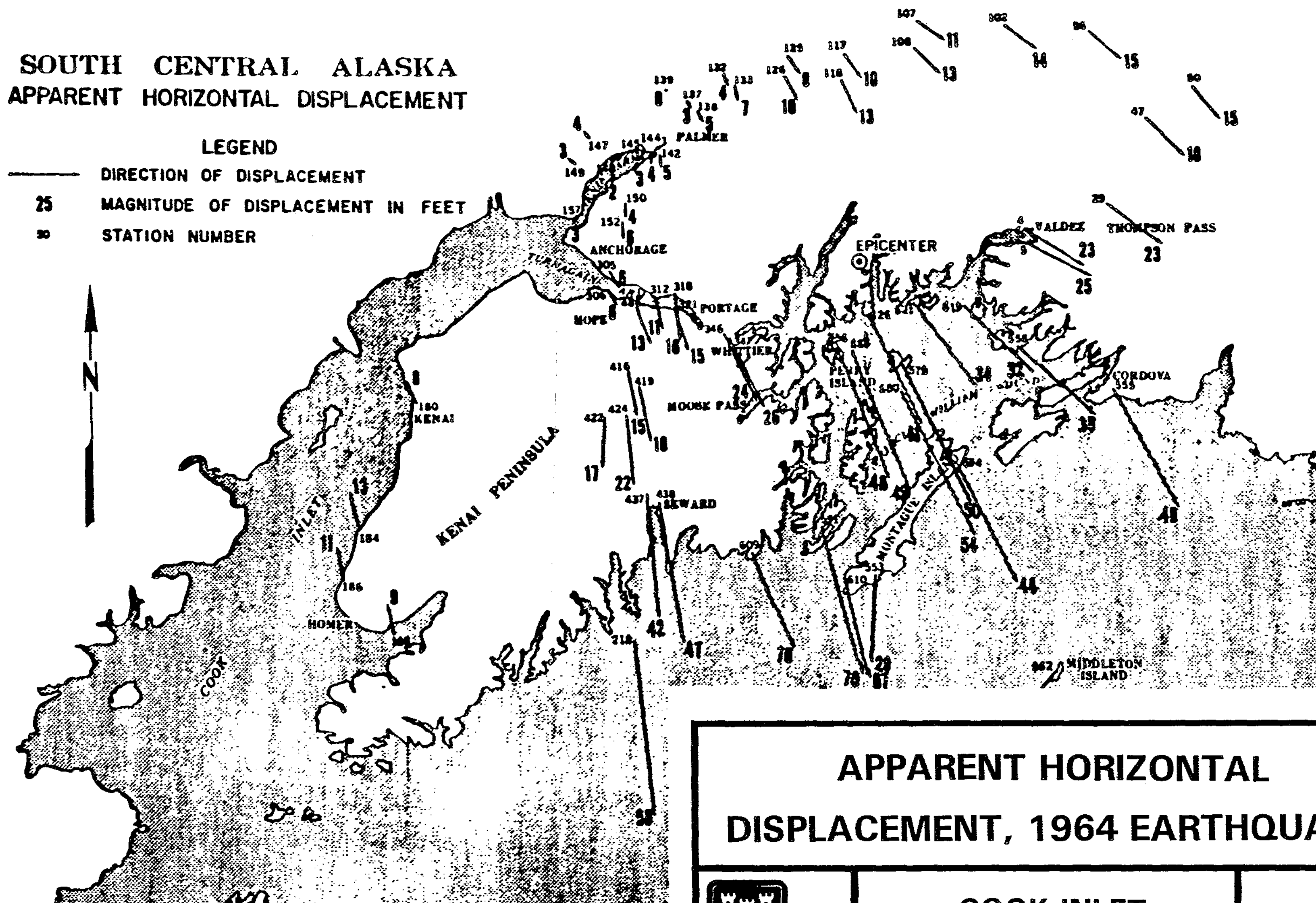

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APPARENT HORIZONTAL DISPLACEMENT, 1964 EARTHQUAKE

US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

2-5

By the end of the Tertiary period, the major topographic elements of the area were established. The major highlands, including the Chugach, Talkeetna, and Alaska mountain ranges, had been raised. The Cook Inlet-Susitna Basin existed much as it is today. Since this period, several major glaciations have altered the landscape of the Cook Inlet region. During the Pleistocene age, 2 million to 10,000 years ago, glaciers pushed beyond the mountain fronts into the lowlands, depositing sediment and debris up to several thousand feet thick.

As the glaciers receded, Cook Inlet assumed its present form. The lowlands, no longer well drained, are covered with numerous lakes and swamps. Ice scouring left the harder rock ridges, while depositing the scoured, softer sediment on the lower valleys.

2.1.4 Mineral Resources. Coal, oil and gas, sand and gravel, and various minerals exist in substantial quantities throughout the Cook Inlet Basin. Coal within the basin was formed as the gradient or slope of the streams within the basin became gentler. This gentler slope reduced the velocity of water in the streams, which allowed finer sediment to be deposited. This in turn allowed vegetation to grow and die, forming successive layers of peat. This organic accumulation alternated with layers of sand and clay. As the layers increased, pressure gradually changed these beds of peat to coal.

The coal found in the inlet basin is principally lignite, a soft coal that is brown to black. Lignite is referred to as "steam coal." Its relatively low heating value and fixed carbon content make it suitable for use in electrical generation or production of methanol (Alaska Transportation Consultants, Inc. 1985, 3-10).

The major coal reserves within the Cook Inlet region lie in three distinct areas: the Beluga field to the northwest, the Matanuska field to the northeast, and the Kenai field in the western Kenai Peninsula. The largest coal field is the Beluga River deposit, located in the Susitna Lowlands in the vicinity of the Beluga and Yentna Rivers. This deposit contains at least 2.3 billion tons of coal; the energy is equivalent to at least

7 billion barrels of oil (USACE Alaska District 1972, V-22). However, the only operating coal mine in Alaska is located north of the Cook Inlet Basin in the town of Healy. Although cost has prohibited the commercial extraction of coal from the Cook Inlet Basin, nearly 80,000 acres of land in the Beluga, Matanuska, and Yentna coal fields is currently leased by companies. The Beluga field has nearly half of these coal leases (Alaska Transportation Consultants 1985, 3-5 to 3-10). Figure 2-6 shows the location of coal fields within the Cook Inlet area.

Extensive oil and gas fields also occur in the Cook Inlet Basin. In Alaska, the oil and gas resources of Cook Inlet are second only to those found on the North Slope. The deposits exist at depths of 8,000 to 10,000 feet in the Tertiary conglomerates. Cook Inlet has estimated reserves if 7.9 billion barrels of petroleum and 14.6 trillion cubic feet of natural gas (Gatto 1976, 20).

Oil and gas have been produced in Cook Inlet since 1958 in the waters of the upper inlet, on the Kenai Peninsula, and in the Beluga area. Currently, Cook Inlet has the greatest concentration of treatment, refining, and petrochemical facilities in Alaska. Two refineries, a gas petrochemical operation, a gas liquefaction and liquefied natural gas terminal, oil storage and export facilities, and several small treatment and storage facilities exist in the Cook Inlet Basin. The State of Alaska has issued 589 well permits on six active production fields in Cook Inlet. Two of these fields are located on shore, four offshore. By 1990 estimates, 66 million barrels of oil remain in these fields (Cook Inlet Citizens Advisory Commission [RCAC] 1992, 20-37). High volumes of natural gas reserves remain in the inlet. Figure 2-7 shows oil and gas fields of the Cook Inlet area.

Minerals such as copper, silver, gold, zinc, lead, molybdenum, tin, tungsten, graphite, chromite, and iron ore are also found throughout the basin. Large low-grade chromite deposits occur near the southwest tip of the Kenai Peninsula. Resources in the northern portion are relatively well distributed; in the southern half they are found only in a few

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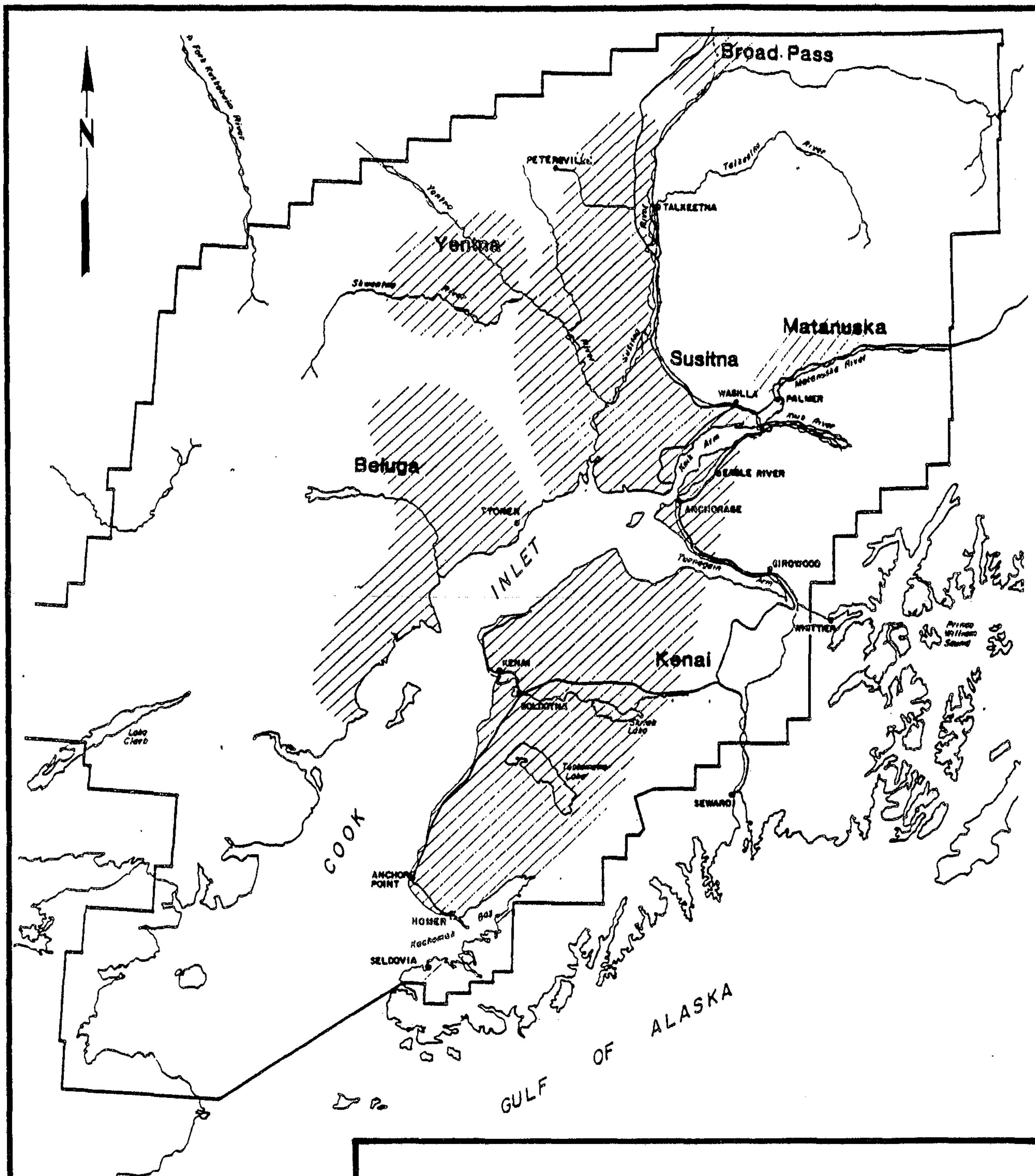

LOCATIONS OF COAL DEPOSITS

US Army Corps of Engineers
Alaska District

COOK INLET
NAVIGATION

2-6

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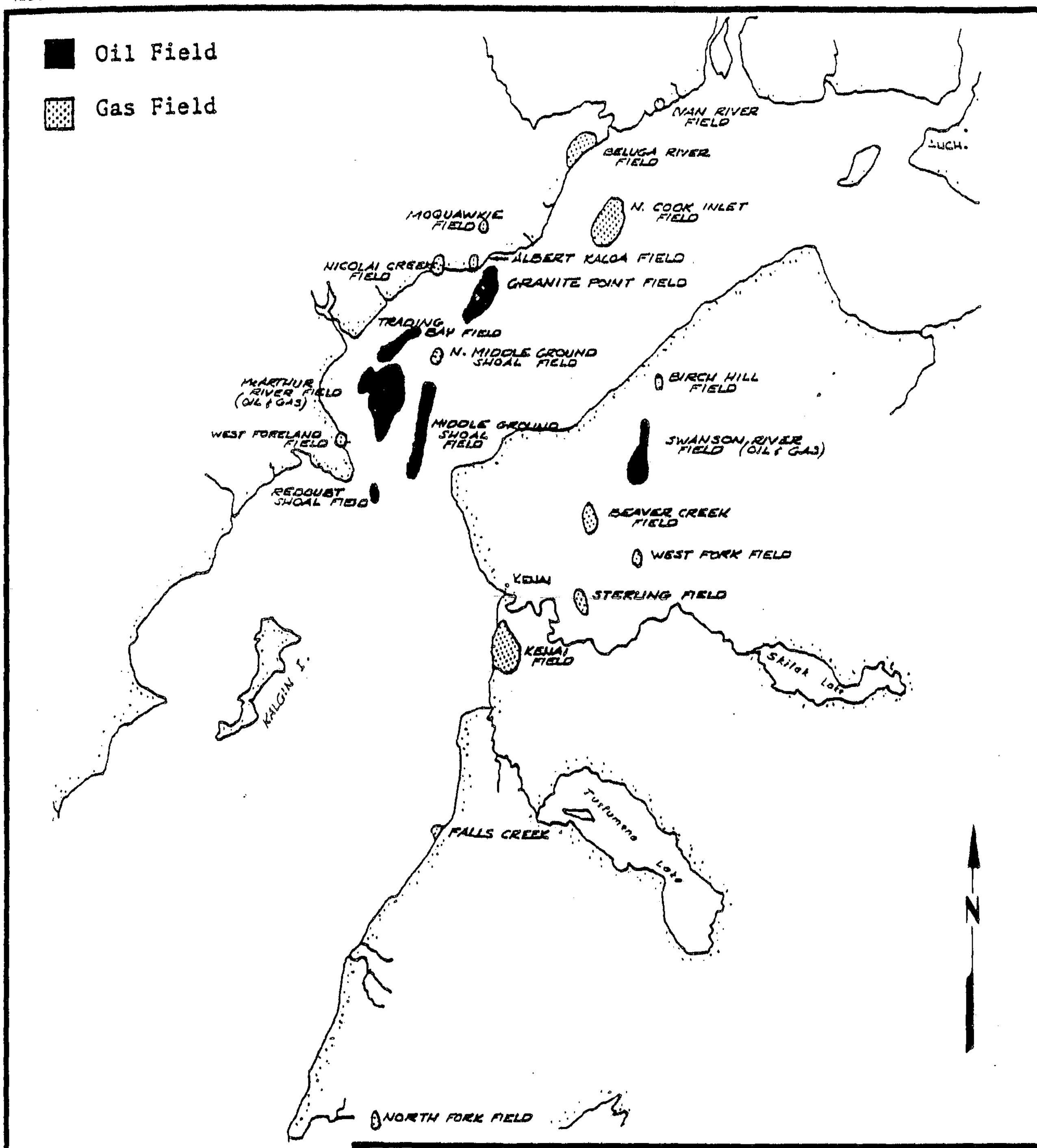

N.T.S.

Source: U.S. Army Corps of Engineers, 1972

OIL AND GAS FIELDS

US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

2-7

discrete locations. Placer gold operations are currently the most common mining activity. Figure 2-8 shows mineral resource locations within the Cook Inlet area.

The Cook Inlet area is rich in sand and gravel. Sand and gravel deposits are found extensively along the shore of Cook Inlet and throughout its flood plains and glacial deposits.

Finally, large deposits of peat exist throughout the inlet. Peat is commonly used as fertilizer, stable litter, absorbent, and disinfectant. An estimated 61.7 billion tons of peat lie within the basin, constituting an enormous source of energy (Alaska Transportation Consultants, Inc. 1985, 3-84 to 3-85). However, the economics of using peat as anything other than fertilizer are such that development as a fuel source is not likely to occur in the near future.

2.1.5 Oceanography. The following paragraphs describe characteristics of Cook Inlet's depth (bathymetry), tides, waves, and circulation patterns. The subsection concludes with a discussion of Cook Inlet ice. Further discussion of Cook Inlet oceanographic characteristics can be found in Appendix B, Engineering.

The inlet above the East and West Forelands is a shallow basin, with depths generally less than 100 feet. Located in this upper portion of the inlet are the mouths of the Matanuska, Knik, and Susitna Rivers. These three rivers contribute approximately 70 percent of the fresh water discharged annually into the inlet. Table 2-1 lists the average, maximum, and minimum recorded flows of these rivers. These rivers are glacier-fed and carry a heavy sediment load, particularly during the summer months. For example, the rivers entering Turnagain Arm discharge nearly 3 million tons of sediment annually, while the rivers entering Knik Arm discharge about 20 million tons (Gatto 1976, 18).This sediment continues to fill the upper inlet. Knik Arm averages 50 feet in depth for about half of its length and then rapidly shallows to a tidal flat. Turnagain Arm shallows

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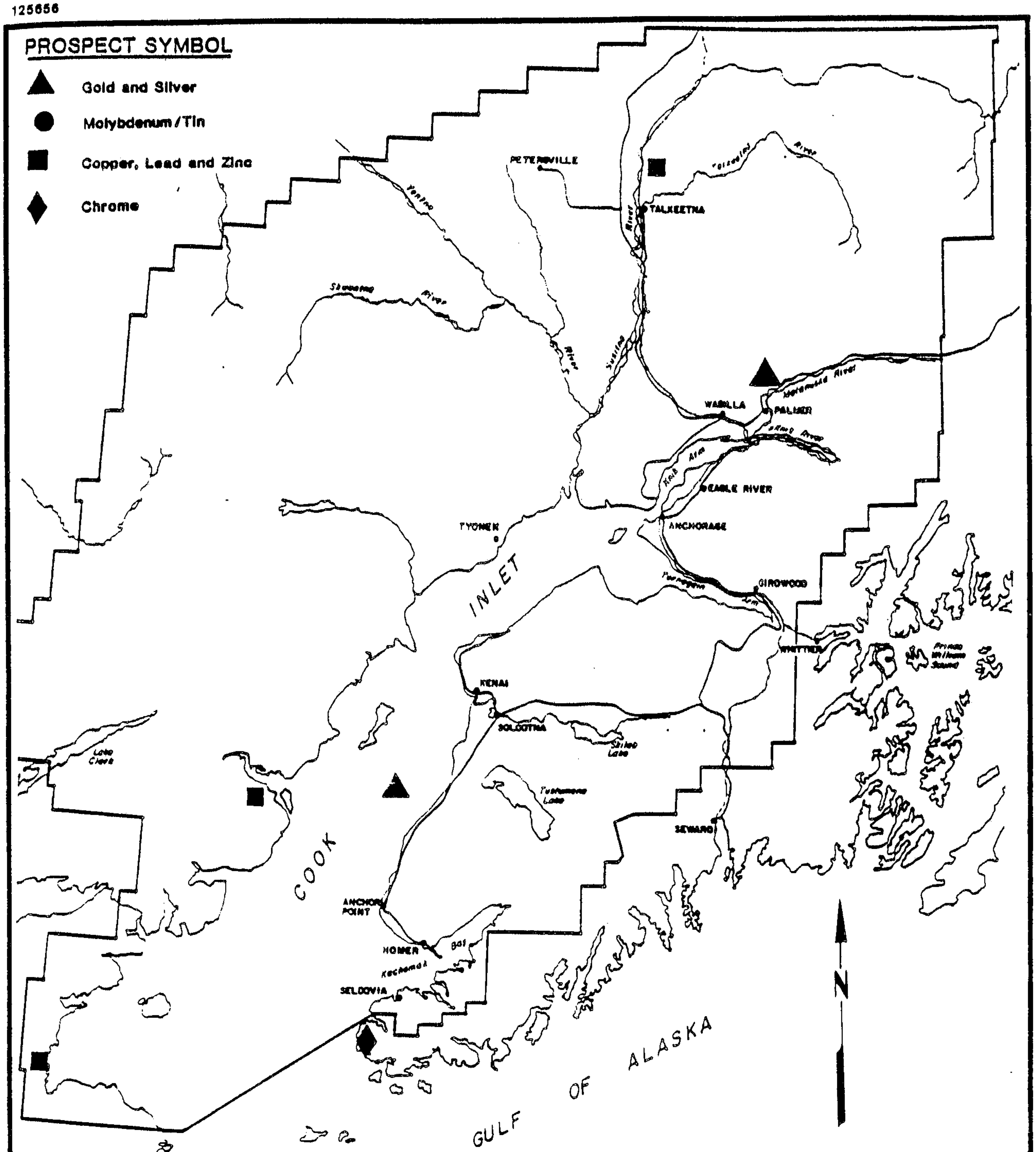

MINERAL RESOURCE LOCATIONS

N.T.S.
Source: Alaska Transportation Consultants, 1985

US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

2-8

TABLE 2-1.--*Average, maximum, and minimum recorded flows for the Matanuska, Knik, and Susitna Rivers*

River	Gauge location	Average flow (ft^3/s)	Maximum flow (ft^3/s)	Minimum flow (ft^3/s)
Matanuska	Palmer	3,826	82,100	236
Knik	7 mi S. of Palmer	690	359,000	260
Susitna	1.5 mi downstream of the Yentna River	50,740	312,000	5,000

Source: USGS, "Water Resources Data, Alaska," water years 1991, 1988, and 1986.

within the first 10 miles to a large tidal flat cut by many tidal channels. Tidal marshes are prevalent around the mouth of the Susitna River; in Chickaloon, Trading and Goose Bays; in the Palmer Hayflat at the head of Knik Arm; and in Potter Marsh within the Anchorage coastal area.

Cook Inlet depths near the forelands average 120 feet. South of the East and West Forelands, the inlet bottom slopes downward to depths of more than 600 feet just outside the inlet mouth at the Barren Islands. Bottom topography is rugged in the lower inlet; many deep areas are interspersed with sandy shoals and rocky pinnacles. Average depth in the lower Cook inlet is 300 feet. However, Kamishak Bay in the lower west end of the inlet is generally shallow, with depths less than 100 feet. Deep areas (more than 300 feet) lie in Kachemak Bay near Yukon Island and in an area just east of Harriet Point near the Forelands. Figure 2-9 shows the generalized bathymetry of Cook Inlet.

Cook Inlet has the second highest tides in all of the Americas, exceeded only at the Bay of Fundy in Nova Scotia (Anthony and Tunley 1976, 156). Mean daily tide range varies

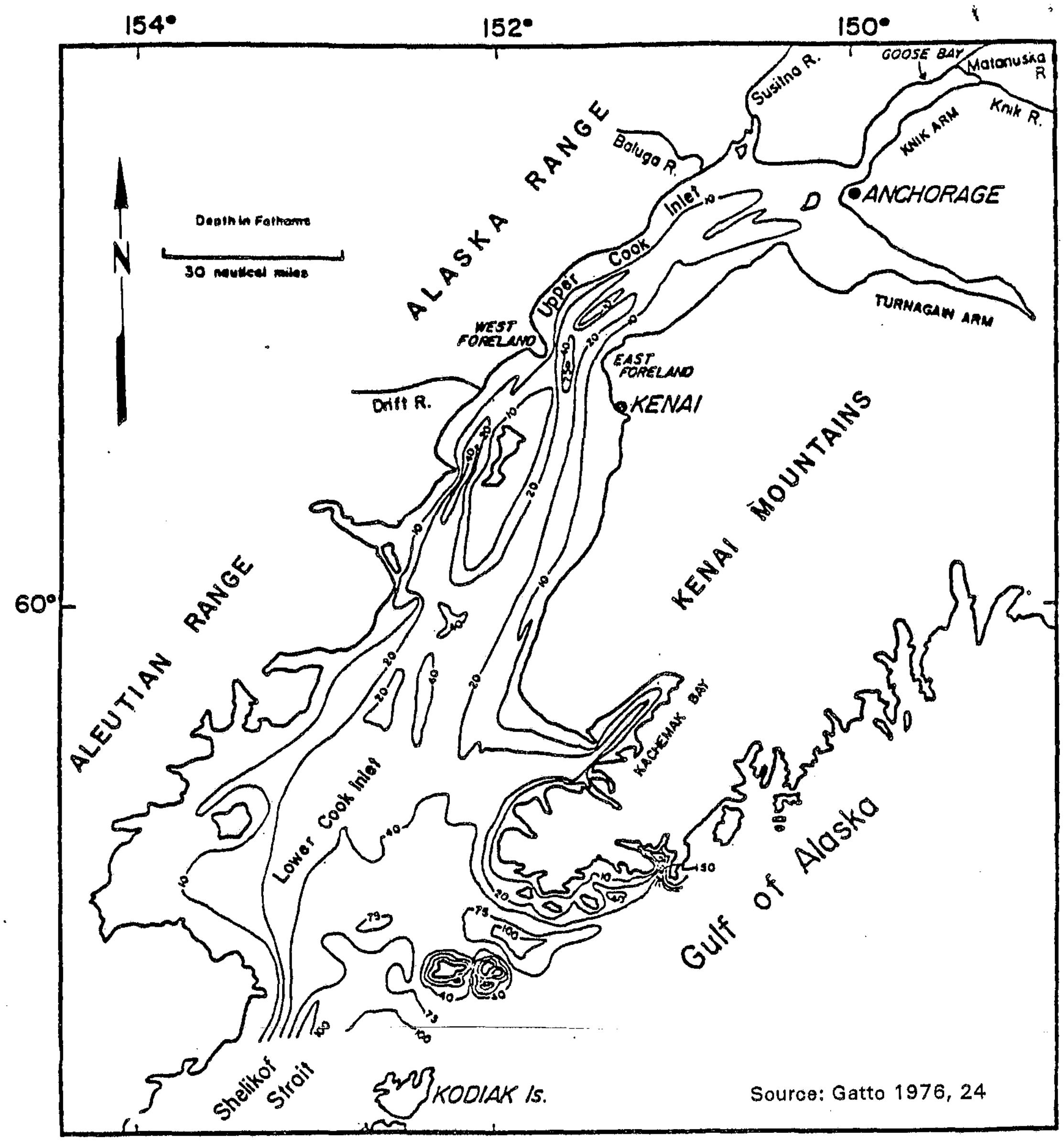

FIGURE 2-9.--Generalized bathymetry of Cook Inlet.

from 13.8 feet at the mouth of the inlet to 29.5 feet at Anchorage. The tides in the inlet occur as two unequal high tides and two unequal low tides per tidal day. A tidal (lunar) day is 24 hours and 50 minutes. The greatest tides occur in the spring, with high and low tides exceeding the mean by more than 5 feet. Tides vary within the lower portion of the inlet from 19.0 feet on the east side to 16.7 feet on the west side. The high tide range creates especially strong currents along the eastern shore of the lower inlet. High tide at the mouth of the inlet occurs approximately 4-1/2 hours before high tide at Anchorage (Gatto 1976, 25). Tables 2-2 and 2-3 list tidal ranges and currents

TABLE 2-2.--*Tidal ranges for various locations within Cook Inlet*

Site	Location within inlet	Tidal ranges: Mean[a] (ft)	Tidal ranges: Diurnal[b] (ft)
Port Graham	Southeast end	14.5	16.9
Nordyke Island, Kamishak Bay	Southwest end	12.9	15.2
Kenai	Mid-east	17.5	19.8
Drift River Terminal	Mid-west	15.4	18.1
Anchorage	North end	25.9	28.8

[a] Mean tidal range is the difference in height between mean high water and mean low water.
[b] Diurnal tidal range is the difference between mean higher high water and mean lower low water.
Source: U.S. Department of Commerce, NOAA 1992b, 187.

TABLE 2-3.--*Current ranges for various locations within Cook Inlet*

Site	Location within inlet	Current ranges: Maximum flood current (knots)	Current ranges: Maximum ebb current (knots)
Cape Elizabeth	Southeast end	2.2	1.8
Cape Douglas (NE of)	Southwest end	0.7	1.5
Kenai (6 mi. SW of)	Mid-east	2.4	2.6
Drift River Terminal	Mid-west	1.9	3.1
Anchorage (west of)	North end	3.5	3.1

Source: U.S. Department of Commerce, NOAA 1992b, 187.

respectively for locations in the southeast, southwest, mid-east, mid-west, and north parts of the inlet.

Water in lower Cook Inlet generally circulates in a counterclockwise pattern. Less turbid, more saline Gulf of Alaska water enters at the southeast end of the inlet, and sediment-laden fresher water flows out along the west side. Tidal currents in lower Cook Inlet are classified as rotary currents, since the flow typically does not slow to zero velocity, but rather changes direction through all points of the compass. Tidal currents are superimposed on the longer-term net circulation trends. The upper inlet experiences vertical mixing of water during each tidal cycle, while the lower inlet tends to be more stratified in temperature and salinity. Currents in the upper inlet are classified as reversing currents, as the flow changes to the opposite direction and is briefly near zero velocity at each high and low tide. Extreme tides can cause currents to exceed 6 knots in some areas, although currents are typically less than 3 knots throughout most of the inlet (USACE Alaska District 1972, II-5, 6). The upper inlet's shallow depths usually restrict wave heights to 10 feet or less. Waves near Beluga can reach 15 feet in height, while waves of greater than 20 feet can occur south of Kachemak Bay (Peratrovich, Nottingham and Drage, Inc. 1993, 8). Figure 2-10 shows the general circulation pattern of water within Cook Inlet.

Cook Inlet ice forms in four different ways. The most predominant type of ice that forms in the inlet is sea ice. Sea ice forms in seawater as a thin layer which increases in thickness as layers are added to the bottom. Sea ice can exist in the inlet as floes greater than 1,000 feet wide and up to 3 feet thick. Pressure ridges up to 18 feet sometimes form as these floes collide (Gatto 1976, 76). Beach ice is a second type of ice which forms in the inlet. Beach ice quickly forms on tidal flats as the seawater contacts the frozen tidal mud. Beach ice rarely gets thicker than 2 feet before floating free of the mud. This floating beach ice often deposits in layers on the mudflats during high tides. These deposits often turn into *stamukhi*, the third type of Cook Inlet ice. *Stamukhi* is created when overhanging pieces of deposited beach ice break off as the tides

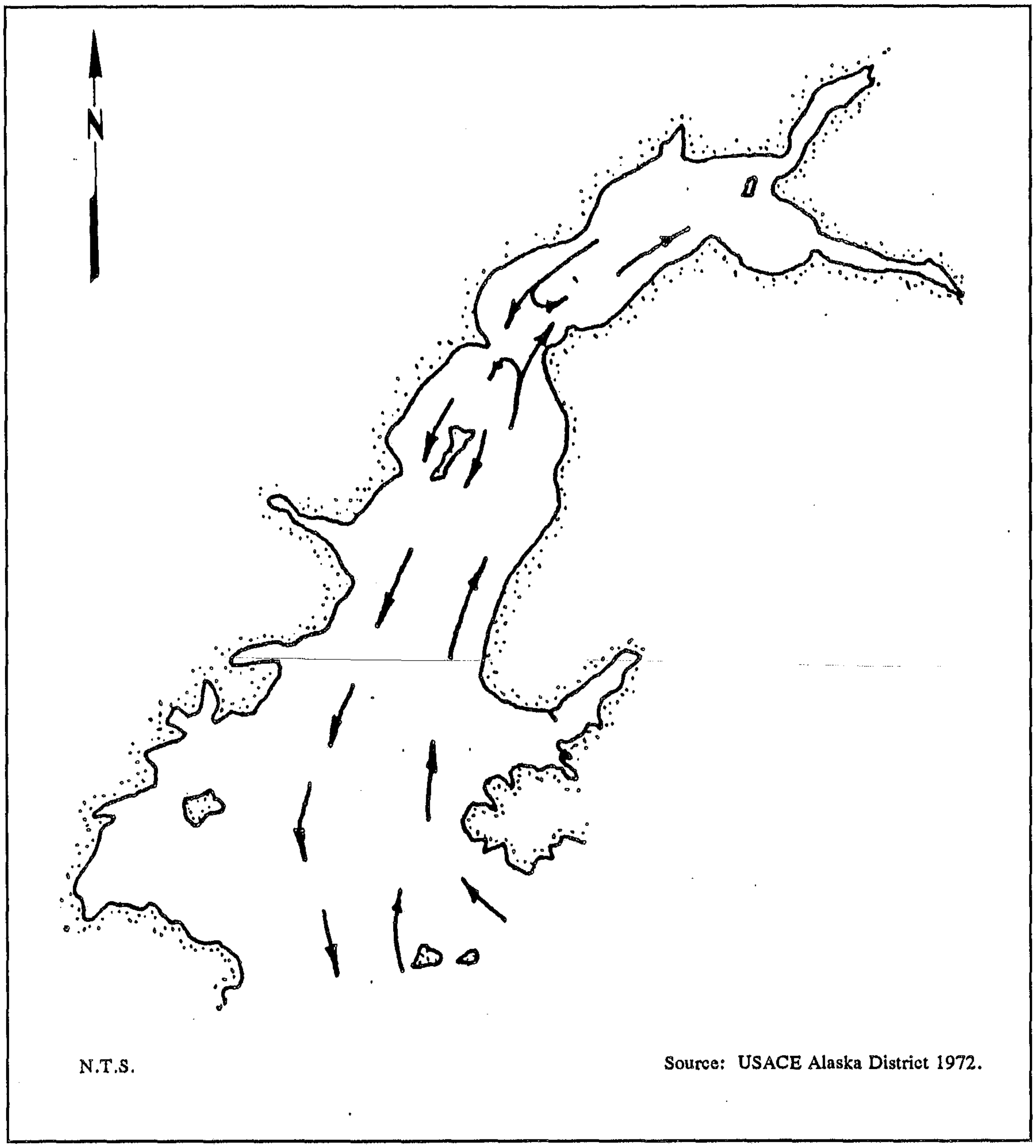

FIGURE 2-10.--Surface circulation pattern, Cook Inlet.

recede, leaving behind layered ice with nearly straight sides. These forms occasionally break free during high tides and are carried into the inlet. Beach ice and *stamukhi* are the last forms of ice to melt in the spring. The final type of ice found in Cook Inlet is estuary or river ice. This type of freshwater ice, similar to sea ice but much harder, is often discharged into the inlet during the spring breakup (LaBelle and others 1983, 161-164).

Ice can be a navigational hazard, particularly in the upper inlet, for as long as 5 months of the year. The ice that forms in the less saline waters of the upper inlet is harder than the ice that forms in the lower portions of the inlet. As a result, upper-inlet ice is more dangerous to ships and fixed structures (WAPORA, Inc. 1981, 3-16). Cook Inlet ice typically first forms in October, but does not cover a significant area of the inlet until late November. By December, ice north of the forelands typically covers about half of the water surface, but the southern portion of the inlet is generally open water. Cook Inlet often warms in late December and early January, with little to no increase in ice coverage or thickness during this warming period. By the end of January, ice thickness in the inlet ranges from less than 2 feet to more than 6 feet. (LaBelle and others 1983, 161-175). During a severe winter, continuous pack ice may extend as far south as Anchor Point on the east and Cape Douglas on the west (WAPORA, Inc. 1979, 3-16).

Table 2-4 lists the dates of the first significant ice and ice-free dates for Cook Inlet for the winters of 1972-73 to 1981-82. Figure 2-11 shows the mean ice formations for January 16 through February 15.

In late March or early April, the only ice remaining in the inlet is the large chunks of beach ice and *stamukhi*. On rare occasions ice will persist until May (Gatto 1976, 76). The highest concentrations of sea ice occur in the northern inlet and in the western portion of the southern inlet. The relatively warm seawater found in the eastern portion of the lower inlet keeps this area generally ice-free during the winter months. Northerly winter winds move free-floating ice to the west and southwest sides of the inlet. Large ice floes are commonly carried as far south as Kamishak Bay and beyond Cape Douglas (Gatto 1976, 76).

TABLE 2-4.--*Mean ice formations for Cook Inlet, 1972-82*

Year	First ice	Ice-free
72-73	November 13	April 10
73-74	November 18	April 6
74-75	November 24	April 9
75-76	November 12	April 10
76-77	December 17	April 9
77-78	November 20	March 18
78-79	December 16	March 31
79-80	December 12	March 26
80-81	December 6	March 10
81-82	November 20	April 19
Average	November 28	April 2

Source: LaBelle and others 1983, 161.

2.1.6 Living Resources.

Vegetation. The tidal flats which extend toward the inlet from about the mean high tide line consist of exposed mudflats vegetated only by algae. Above the tide line, the vegetation is dominated by various grass species such as creeping alkali grass and seaside arrowgrass, interspersed with patches of mud colonized by glasswort. The marshes contain a diverse interspersion of wetland, wet meadow, and grass-forb communities.

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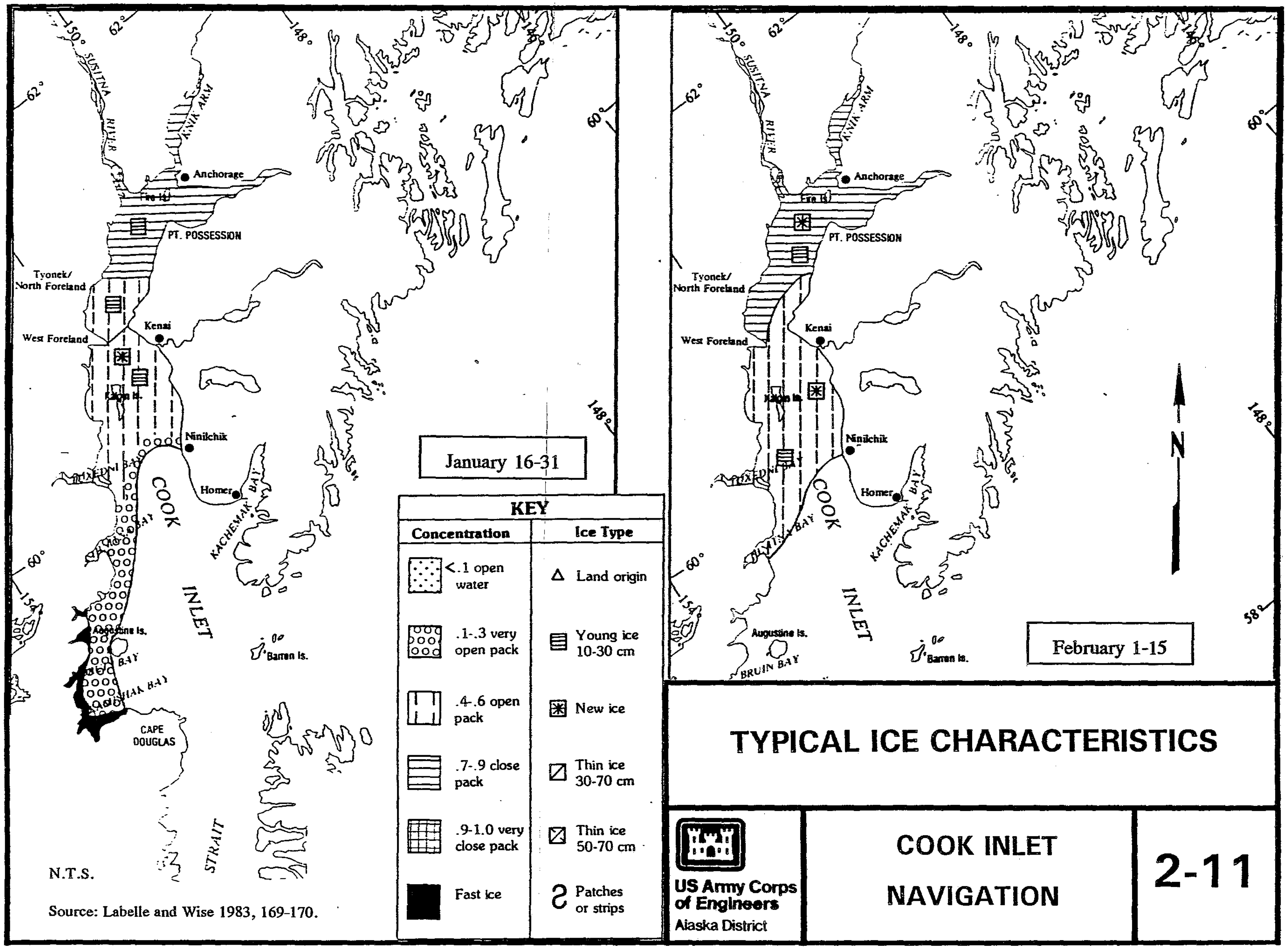

January 16-31
February 1-15
SUSITNA RIVER
KNIK ARM
Anchorage
Fire Is.
PT. POSSESSION
Tyonek/ North Foreland
West Foreland
Kenai
Kalgin Is.
Ninilchik
Homer
KACHEMAK BAY
COOK INLET
Augustine Is.
Barren Is.
BRUIN BAY
CAPE DOUGLAS
STRAIT
N
N.T.S.
Source: Labelle and Wise 1983, 169-170.
KEY
Concentration
<.1 open water
.1-.3 very open pack
.4-.6 open pack
.7-.9 close pack
.9-1.0 very close pack
Fast ice
Ice Type
Land origin
Young ice 10-30 cm
New ice
Thin ice 30-70 cm
Thin ice 50-70 cm
Patches or strips
TYPICAL ICE CHARACTERISTICS
US Army Corps of Engineers
Alaska District
COOK INLET NAVIGATION
2-11

Interior spruce-birch forests dominate the lower slopes and stream valleys. Nearly 75 percent of the Cook Inlet-Susitna lowlands are forested with white spruce, paper birch, and quaking aspen. Sitka spruce is common around the mouth of the inlet, and cottonwood is found along major streams. Black spruce occurs in wet or burned areas; muskeg, usually treeless, occasionally supports some stunted black spruce (Gatto 1976).

The mountains surrounding the inlet are very steep and rugged, with distinct tree lines. Bedrock is exposed above the tree line. Scrubby alpine vegetation occurs on the lower slopes; black spruce forests or grasslands exist in a few areas. Higher elevations of the surrounding ranges are covered with ice fields and valley glaciers. Approximately 90 percent of the Kenai, Chugach, and Talkeetna Mountains are nonforested. Sitka spruce and western hemlock are the dominant tree species in the Chugach Range.

Animal Life. The following paragraphs introduce the animal life -- the invertebrates, fish, birds, and marine mammals -- in the waters of Cook Inlet and in the surrounding tidelands, forests, and mountains. Discussion is limited to the fauna primarily present in upper Cook Inlet north of the forelands.

Plankton and Intertidal Organisms. Plankton abundance is a measure not only of the productivity of a body of water, but also of the food supply for higher forms. Phytoplankton surveys (Rosenberg and others 1967, Murphy and others 1972, Kinney and others 1970) in Cook Inlet indicate that numbers of species and abundance increase as one moves down the inlet toward the ocean. Primary production appears to be limited in the upper inlet by reduced light penetration from high suspended sediment loads, and photosynthesis is confined to a shallow photic zone. The high silicate content of incoming sediments and the high silicate content of inlet waters appear to favor the growth of diatoms, which are by far the dominant phytoplankters.

The surveys of plankton in upper Cook Inlet listed species of *Cladocera*, *Copepoda*, *Protozoa*, and *Rotifera* in Knik Arm. The relatively low diversity and abundance of zooplankton (except copepods) suggest that debris, silt, and low salinity at certain times of the year severely restrict the survival of zooplankton.

Intertidal benthic invertebrates from upper Cook Inlet comprise a mixture of marine and freshwater animals. Beach cores indicated that the only living marine infaunal organism was the small estuarine clam, *Macoma bathica*. Nudibranchs (*Placida dendritica*) were collected from beds of macroscopic algae (*Vaucheria longicaulis*), which form a zone at least 50 meters wide on mudflats between Anchorage and Point Campbell. Numerous epifaunal true bugs and a few adult flies were found in the marsh south of Point Woronzof. Terrestrial organisms (especially insects) may comprise half of all salt marsh animals. Detritus is the main energy source in salt marshes, although benthic algae are consumed by some snails and birds. Gammarid amphipods are present in this general region (USACE and Municipality of Anchorage 1979).

Subtidal benthic organisms are sparse in upper Cook Inlet. Studies in the Point Woronzof region indicated it is one of the poorest areas for marine organisms. Burial of organisms by silt, subtidal erosion and scouring of the seafloor by sediment and ice, exceptionally high turbidity, rapid currents, low temperatures, and low and fluctuating salinity all combine to create an unusually severe estuarine environment (USACE and Municipality of Anchorage 1979).

<u>Fish</u>. Upper Cook Inlet supports a sport fishery of five species of salmon as well as Dolly Varden and eulachon. These anadromous fish are usually taken from local creeks and rivers rather than in Knik and Turnagain Arms, except for eulachon which are dipnetted from tidal channels in Turnagain Arm. The part of upper Cook Inlet comprising the Knik Arm drainages, the Anchorage area, and the east Susitna River drainages is the focus of a sport fishing effort in which 129,359 angler days were expended in 1991. This effort constitutes 15.4 percent of the total sport-fishing angler days for the Southcentral region of the State. The type of fish sought are primarily adult salmon; the annual catch in 1991 was 126,103 fish (Mills 1992).

For commercial salmon fisheries management, the Alaska Department of Fish and Game divides upper Cook Inlet into the Central and Northern Districts. The main salmon spawning drainages are shown in figure 2-12. The Northern District is split into two subdistricts north of the forelands. The major salmon stream in this area is the Susitna River. Only set gill-netting is allowed in the Northern District. The fishing season generally extends from the end of June until mid-August. Examination of commercial harvest data collected since 1954 revealed that recent returns of salmon to upper Cook Inlet are at record or near record levels. This is attributed largely to theextremely strong sockeye salmon return to the Kenai River. The Susitna River had weak returns of sockeye, pink, and chinook salmon in 1992. Salmon harvested in the northern district in 1992 totaled 207,361 fish (Ruesch 1992). The Northern District set gill-net harvest data from 1966 through 1991 is presented in table 2-5.

A subsistence chinook salmon fishery with an allowable harvest of 4,200 fish was established near Tyonek in 1981. Chinook harvests in this fishery have ranged from 797 to 2,750 salmon. In 1986 a personal use dip-net fishery was established at the mouth of Fish Creek for sockeye salmon. The Fish Creek dip-net fishery begins when the sockeye salmon escapement is projected to exceed 50,000 (Waltemyer 1991). Since 1987 this fishery has occurred each year, with harvests ranging from 2,200 to 6,500 salmon. A set-net subsistence fishery was created in 1991 in Knik Arm under the Upper Cook Inlet Subsistence Salmon Management Plan. The annual bag and possession limits for this fishery were established at 25 salmon per permit holder, of which no more than 5 can be chinook salmon. Another set-net fishery, open to all Alaska residents holding a sport fishing license, was created by the Board of Fisheries in 1983 under the Central and Northern District Personal Use Coho Salmon Management Plan. Gear is limited to set gill nets; the harvest limit is 25 salmon per head of household, with an additional 10 salmon per household member. The open area for this fishery is from 1 mile north of the Kasilof River to Point Possession. The subsistence fishery is now managed by the Upper Cook Inlet Subsistence Salmon Management Plan. Harvests have ranged from 712 to

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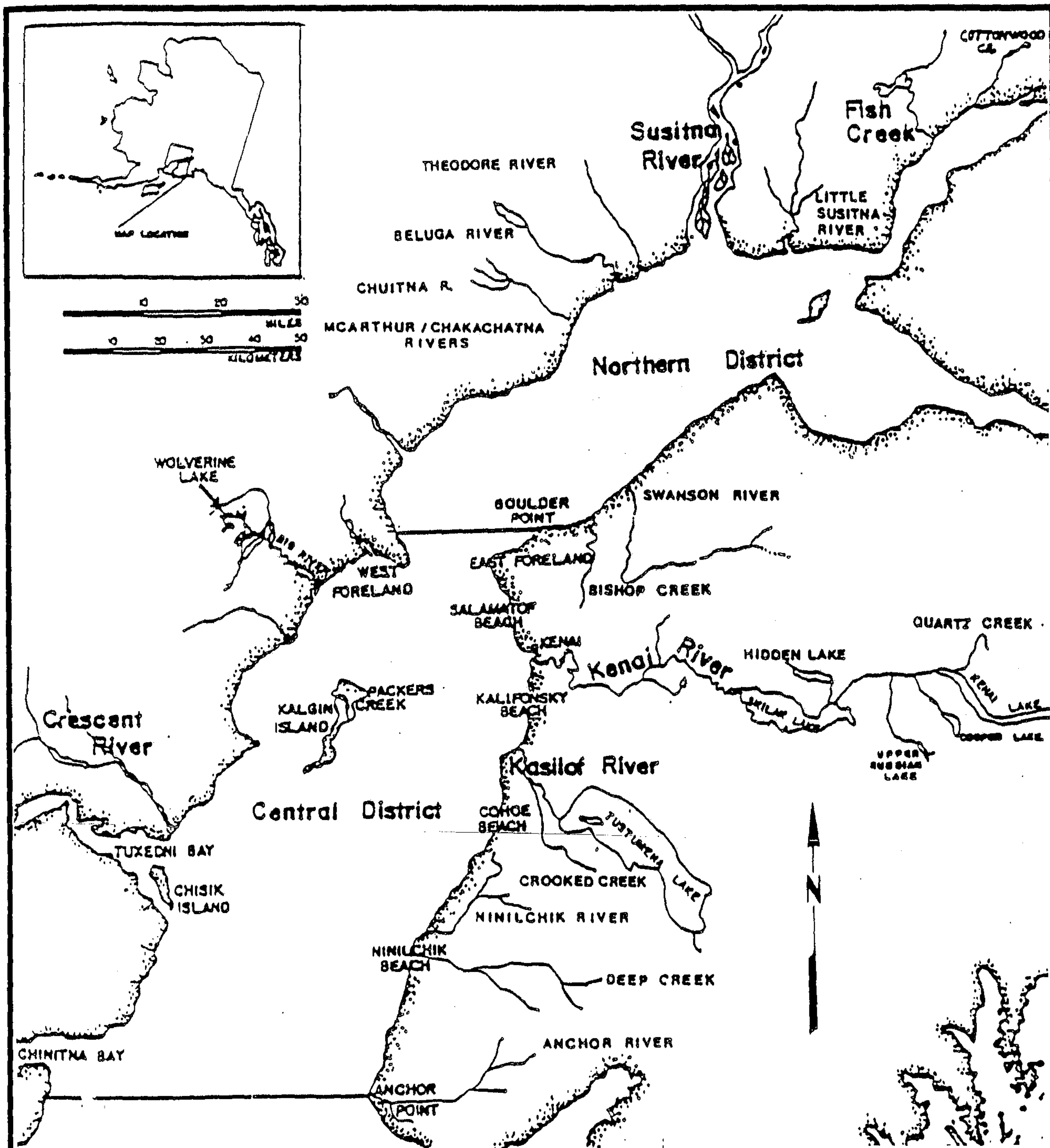

PRIMARY SALMON SPAWNING DRAINAGES

Source: ADF&G.

US Army Corps of Engineers
Alaska District

COOK INLET
NAVIGATION

2-12

TABLE 2-5.--*Upper Cook Inlet commercial salmon harvest by gear type and area, 1966-1991*

Year	Central District drift gill net		Central District set gill net East side		Central District set gill net Kalgin/West side		Northern District set gill net		
	Number	%	Number	%	Number	%	Number	%	Total
1966	2,203,180	47.0	1,538,621	32.8	327,585	7.0	619,610	13.2	4,688,996
1967	1,184,228	62.6	364,541	19.3	135,249	7.1	208,947	11.0	1,892,965
1968	2,612,714	52.6	1,189,117	24.0	269,670	5.4	890,987	18.0	4,962,488
1969	652,011	59.0	247,514	22.4	125,541	11.4	80,910	7.3	1,105,976
1970	1,641,429	62.1	460,676	17.4	189,798	7.2	349,340	13.2	2,641,243
1971	739,835	66.3	153,374	13.7	125,986	11.3	97,251	8.7	1,116,446
1972	1,207,217	54.1	643,323	28.8	160,443	7.2	220,605	9.9	2,231,588
1973	1,105,354	62.3	299,616	16.9	130,542	7.4	237,824	13.4	1,773,336
1974	827,141	52.2	471,210	29.7	118,352	7.5	168,141	10.6	1,584,844
1975	1,457,277	66.5	340,625	15.5	173,510	7.9	220,446	10.1	2,191,858
1976	2,142,563	59.4	1,012,991	28.1	183,952	5.1	270,096	7.5	3,609,602
1977	2,626,455	64.9	912,023	22.5	223,362	5.5	285,347	7.1	4,047,187
1978	3,304,925	64.6	1,085,009	21.2	265,302	5.2	464,150	9.1	5,119,386
1979	1,199,085	62.3	308,166	16.0	216,395	11.2	202,400	10.5	1,926,046
1980	2,165,142	53.7	911,327	22.6	269,750	6.7	687,951	17.1	4,034,170
1981	1,672,457	57.8	558,657	19.3	180,338	6.2	484,282	16.7	2,895,734
1982	4,139,886	65.7	1,530,966	24.3	303,249	4.8	322,441	5.1	6,296,542
1983	4,621,365	68.2	1,582,746	23.4	277,819	4.1	289,944	4.3	6,771,874
1984	2,290,273	59.3	758,174	19.6	298,978	7.7	515,766	13.4	3,863,191
1985	3,127,467	55.7	1,671,259	29.8	472,238	8.4	341,272	6.1	5,612,236
1986	4,969,254	62.0	2,291,571	28.6	296,292	3.7	460,468	5.7	8,017,585
1987	6,088,837	58.3	3,656,473	35.0	342,782	3.3	361,608	3.5	10,449,700
1988	5,217,224	60.7	2,687,819	31.2	274,593	3.2	422,229	4.9	8,601,865
1989	819	0.0	4,686,002	84.2	304,209	5.5	575,068	10.3	5,566,098
1990	3,166,684	62.6	1,391,505	27.5	174,066	3.4	325,035	6.4	5,057,290
1991	1,514,519	52.0	884,539	30.4	212,787	7.3	299,876	10.3	2,911,721
Average[a]	2,475,061	59.8	1,078,074	26.1	229,943	5.6	353,077	8.5	4,136,155

[a] Figures from 1989, the year of the Exxon *Valdez* oil spill, are excluded from the average.
Source: Alaska Department of Fish and Game.

more than 11,000 coho salmon (Fox and Ruesch 1992). Figure 2-13 illustrates Upper Cook Inlet subsistence gill-net and dip-net fishing areas.

Other fish in upper Cook Inlet north of the forelands include Dolly Varden (distributed throughout Cook Inlet), herring smelt, and small flounders. Although starry flounder, Pacific tomcod, and lemon or English sole are recorded from the Point Woronzof region, demersal fish, in particular, probably occur in very low populations due to severe environmental conditions and lack of food. Dolly Varden, humpback whitefish, and five species of salmon migrate into local creeks. Anadromous stickleback (threespine and ninespine) have been reported in Knik Arm (USACE and Municipality of Anchorage 1979).

A beach-seining fish sampling program was conducted in Knik Arm for the environmental analysis of the proposed Knik Arm Crossing Project (Dames and Moore 1983). Eighteen species of fish were captured, adding to the knowledge of the fish populations of this part of the inlet. The species included all of the abovementioned fish with a few exceptions. Bering cisco and saffron cod were caught consistently enough to question, in the researcher's mind, whether the humpback whitefish and the Pacific tomcod were correctly identified near Point Woronzof. Other fish not previously identified included the longfin smelt, Pacific herring, ringtail snailfish, yellowfin sole, Pacific staghorn sculpin, and eulachon. All of the fish species caught except the humpback whitefish and the Pacific tomcod have been reported previously in Cook Inlet (Blackburn 1977). Crustacea caught in the seine nets were primarily crangonid shrimp, mysidacea, amphipoda and isopoda.

Energy for the moderate production of fish and epibenthic invertebrates occurring in Knik Arm is probably provided by organic detritus from adjacent marshes and streams.

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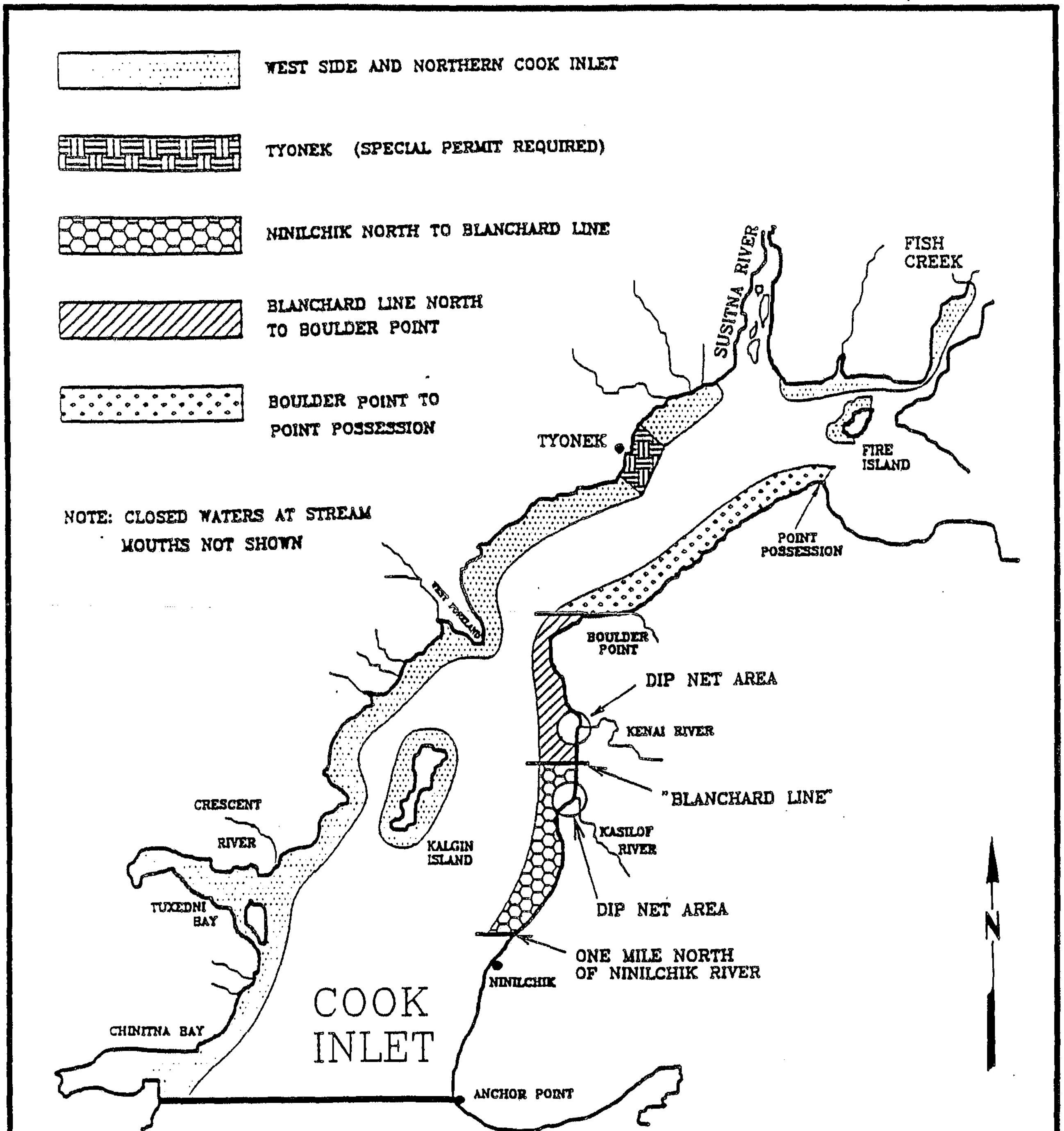

SUBSISTENCE FISHING AREAS

N.T.S.

Source: ADF&G

US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

2-13

Birds. The commonest waterfowl using northern Cook Inlet salt marshes and wetlands are pintails, mallards, green-winged teal, and lesser Canada geese. Among the commonest shore birds are plovers, sandpipers, yellowlegs, dowitchers, and phalaropes. Pintails and mallards are usually the first migrants to arrive in mid-April. Highest population levels occur during spring, when the marshes are used heavily by lesser Canada and snow geese, ducks, and occasional swans and cranes. The Susitna Flats salt marsh in early May has as many as 100,000 waterfowl using the flats to feed, rest, and conduct their final courtship prior to nesting. This refuge also hosts several thousand lesser sandhill cranes. More than 8,000 swans and about 10,000 ducks nest in the Susitna Flats. Shore birds are the first birds to migrate through the area in the fall. Dabbling and diving ducks, swans, and geese begin arriving in late August, peak in numbers by early October, then move outward a few weeks later.

The coastal marshes are recognized as important resting and staging areas for water birds during spring and fall migration. The marshes are also important breeding habitat. These marshes provide hunting and other recreational opportunities in Alaska's most heavily populated area.

The limiting factor for birds in the Point Woronzof/Knik Arm area may be food. Shore birds were found in greatest numbers where there were clams and gammarid amphipods, as well as a rich algal cover. An unvegetated mudflat zone above the algal zone contains almost no macroscopic life. The ducks feed on the mudflat algae. Many insects inhabit the alkali grass. The creeping alkali grass probably is consumed by snow geese and Canada geese during their spring migration. Seaside arrow-grass and other plants provide shelter and possibly food for waterfowl in the uppermost third of the marsh. Stickleback inhabit waters in the upper reaches of large tidal channels. Mew, glaucous-winged, and Bonaparte's gulls and Arctic terns may feed on them (Quimby 1972).

Two subspecies of the peregrine falcon, *Falco peregrinus anatum* and *F. peregrinus tundrius*, are listed as endangered and threatened, respectively, by the U.S. Fish and

Wildlife Service. These birds may pass over the Anchorage area during migration to and from nesting areas farther north. A third subspecies, *F. peregrinus peales*, is known to nest in coastal areas of Southcentral Alaska but is not listed as endangered or threatened.

Marine Mammals. Although 23 species of marine mammals are present in Southcentral Alaskan waters, only a few reach the upper Cook Inlet north of the forelands. Cook Inlet supports an apparently distinct population of 300 to 400 beluga whales during the summer, when the availability of adult salmon and smolt and eulachon apparently accounts for their presence in the area. Harbor seals inhabit Augustine and Shaw Islands and occur on the entire west side of Cook Inlet, with a concentration at the mouth of the Susitna River (Evans and others 1972). Killer whales have been observed in the upper inlet, and minke whales and harbor porpoise have been seen in Turnagain Arm and at the mouths of rivers chasing eulachon. Sea lions have been observed but are rare (personal communication, Brad Smith, National Marine Fisheries Service 1992).

2.2 Human History and Demography

2.2.1 Indigenous People. Both historical and archeological data show that Alaska populations have tended to migrate to the Southcentral region of Alaska, specifically around Kodiak Island, Cook Inlet, and Prince William Sound. The upper Cook Inlet area has been inhabited possibly for as long as 9,000 to 10,000 years. Few archeological sites of this age are known for this area, with the possible exception of Beluga Point, south of Anchorage (Reger 1981). A date of 9,000 years ago is indicated by artifacts found in the lowest level of the Beluga Point site. A more recent component of Beluga Point dates to between 3,000 and 4,000 years ago and shows affinities to the Alaska Peninsula Arctic Small Tool tradition. A slightly later component from a different area of the site resembles a Bering Sea variant of the Norton tradition, which is typified by a greater variety of tools and larger settlements. This component is thought to date to between 2,200 and 2,500 years ago. Two more recent levels are thought to be related to the Kachemak area, dating to about 1,000 years ago. This relatively elaborate culture is also found at the Fish Creek site on the northern shore of Knik Arm. More recent Thule artifacts, such as Thule pottery, are also known in the Cook Inlet area (Dumond 1977).

At the time of the first European contact in the 18th century, the Tanaina Indians inhabited the Cook Inlet region and the Chugachmiut Eskimos lived in northwestern Prince William Sound. The Yukon Island archeological site in Kachemak Bay shows that this area of lower Cook Inlet was occupied by Eskimos from about 1500 B.C. to A.D. 1000, and then by Athapaskan Indians, probably the ancestors of the Tanaina, who moved into the coastal area from the Interior. However, other archeological sites such as Fischer-Hong and Fish Creek indicate there was an Eskimo population in Cook Inlet as recently as 300 years ago and that the Tanaina initially moved into the area from the Copper River between 1650 and 1780 A.D. (Dumond and Mace 1968). Several Tanaina villages were in the Fort Richardson area, the two prominent settlements being Eklutna and Knik. Summer fish camps are known to have existed at the mouth of Ship Creek, Point Woronzof, Fire Island, and the mouth of Eagle River (Steele 1980).

2.2.2 European Exploration.

Russian. Vitus Bering's discovery of Alaska in 1741 triggered the great wave of European exploration of Alaska. By 1790, Russian settlements were scattered from the Aleutian Islands and the Pribilofs to the islands of Southeast Alaska. The first permanent Russian settlement in Southcentral Alaska was founded in 1784 at Three Saints Bay on Kodiak Island. By 1792, permanent Russian settlements had been established along the Kenai Peninsula, from which an active trading operation was carried into Prince William Sound.

English. Captain James Cook, one of England's greatest navigators, sailed for Alaska in 1776 on a 3-year journey looking for a northern passage from the Pacific to the Atlantic.

With two ships, the *Resolution* and the *Discovery*, Cook's expedition sailed north from Nootka Sound, near Vancouver Island, on April 26, 1778. The expedition reached Prince William Sound around the middle of May. After failing to find the passage they were searching for, the two ships turned southward.

On May 21, the southeastern point of Cook Inlet was sighted and named Cape Elizabeth. Russian maps of the time depicted Alaska as an island. Cook, believing Kodiak and Afognak Islands, with Cape Douglas in the foreground, formed part of a mountainous coastline to the west, entered the inlet thinking it was a passage to the Arctic Ocean between the island and the North American continent.

Although he later realized this was not the passage he sought, Cook continued to sail up the inlet, which he thought of as the "Great River" because of the muddy water and floating trees he encountered on the voyage (Bancroft 1886). He anchored his ships southeast of Fire Island. On June 1, the small boats that had been sent out to explore the area returned after discovering the inlet split into two arms, Turnagain and Knik. Sailing south, the ships left Cook Inlet on June 5 and headed southwest along the Alaska Peninsula coastline in search of an opening to the west and north.

Cook's mapping of the Alaska coast became the standard guide for more than a century. He also first proved that America and Asia were not joined.

<u>Spanish</u>. Russian activity in the north did not go unnoticed by the Spanish. Fear of Russian expansion to the south resulted in increased activity by the Spanish in the Pacific. The viceroy of Mexico sent several expeditions north--in 1774, 1777, 1778, and 1790--to take possession of Alaska for Spain. In 1779 a Spanish expedition entered Prince William Sound and claimed it for Spain, the third nation to lay claim to the sound in 2 years. The Russians had claimed it earlier the same year, while Cook, representing England, had done so in 1778. Other than a few place names, such as Valdez and Cordova, Spain left no trace of its northern exploration.

2.2.3 American Rule. The United States bought Alaska from Russia in 1867 for $7.2 million. However, it wasn't until 1912 that Alaska was granted true territorial status with its own legislature. Congress passed the Alaska Statehood Bill on June 30, 1958, and on January 3, 1959, Alaska became the 49th State.

Coal, gold, fishing, and railroad construction played large roles in the development of the Southcentral region.

The start of the commercial fishing industry in Southcentral Alaska can be traced to Karluk on Kodiak Island, where the first fish cannery in the region was established in 1882. During the next 20 years, canneries were established throughout the region. Cook Inlet and Prince William Sound remain important to Alaska's commercial fishing industry.

The Yukon gold rush of 1897 largely bypassed Southcentral Alaska. However, the discovery of gold in Fairbanks in the early 1900's led to the establishment of railroads from Prince William Sound and Cook Inlet to the Interior. Businesses soon sprang up to haul freight from Valdez to Fairbanks over the Richardson Trail.

Immigration into the region from Europe and the United States increased rapidly during the first decade of the 20th century. The construction of a railroad between Cordova and Chitina in 1908 established Cordova as one of Alaska's leading ports, while Valdez maintained its importance as the port of entry to the Richardson Trail.

2.2.4 Important Cities.

Homer. A coal mine operated at Homer's Bluff Point in the late 1800's. A railroad, which was abandoned in 1907, carried the coal out to the end of Homer Spit. Gold seekers heading for the gold fields at Hope and Sunrise disembarked at Homer. Named after Homer Pennock, the town was established around 1896. Homer incorporated as a first-class city in 1964. Coal mining operations stopped around the time of World War I, but settlers continued to move into the area to homestead or to work in the fish canneries that processed Cook Inlet fish. Today Homer calls itself the halibut fishing capital of the world, and its commercial fishing industry remains an important part of its economy.

Seward. The Russians entered Resurrection Bay during the latter half of the 18th century. Alexander Baranov founded a short-lived shipyard near present-day Seward. Named for William Henry Seward, the U.S. Secretary of State who negotiated the purchase of Alaska from Russia, the city was founded in 1903 by surveyors for the railroad which eventually became the Alaska Railroad. The railroad, which runs from Seward to Fairbanks, was completed in 1923. The Federal Government operated the railroad until the State purchased it in 1985.

Seward's original marine terminal was built in 1904 at the south end of the city. From the time of its founding until 1964, Seward was the major port of entry for goods bound for Interior Alaska.

As a major port and the southern terminus of the railroad, Seward was heavily defended during World War II. Two Army garrisons were constructed in 1943 with facilities for about 5,000 troops.

The Seward Highway was completed in 1952, making Seward the only port in the State to be accessible by road, rail, and the Alaska Marine Highway (ferry system).

The 1964 Good Friday earthquake wiped out most of Seward's port facilities and the railroad terminus, and the city lost its supremacy as the major port in the region to its longtime rival, Anchorage. It took Seward's economy 10 years to recover to pre-earthquake levels.

Anchorage. Alaska's largest city was founded as a railroad construction camp at the mouth of Ship Creek in 1915 by the Alaska Engineering Commission (AEC). The commission was mapping a railroad expansion route to connect Seward with the Interior coal fields (Hill 1992). The AEC found the Ship Creek location desirable because of the convenience it afforded in launching railroad construction to the Matanuska coal fields. Although closer to Seward than to Fairbanks, the site served as a "midpoint" between the two. A tent city of approximately 2,000 people immediately sprang up on the north side of Ship Creek underneath the plateau of what is now called Government Hill. In July of that year 655 town lots were auctioned off, and development of a permanent city began.

Originally called Ship Creek, the town later was referred to as Anchorage because of the ships that used to "lie at anchorage" in Knik Arm to allow supplies to be taken ashore. The U.S. Post Office officially gave the town its name when the newly appointed postmaster insisted mail be sent to "Anchorage." Although the AEC protested, its preference for the name Ship Creek was passed over as maps and news accounts quickly adopted the name "Anchorage." In August 1915 voters chose the name Alaska City, but petitions to the Federal Government to change the name were to no avail (Carberry 1979).

On January 1, 1917, the railroad's headquarters were transferred from Seward to the Ship Creek townsite. Anchorage officially incorporated on November 23, 1920, ending the Federal role in operating the Anchorage townsite. The railroad was completed in 1923.

Dock facilities have been located at the mouth of Ship Creek since 1915, when a dock was constructed on the north bank of Ship Creek near the mouth. A gridiron was built in front of the dock; barges were floated over the gridiron during high tide and rested on it during low tide. A 15-ton derrick was available for unloading the barges (Carberry 1979).

Construction on the Ocean Dock began in the summer of 1918. With its opening in September 1919, the earlier dock took on a secondary role. The S.S. *Anyox* was the first oceangoing vessel to use the Ocean Dock. Because steamships could dock at Anchorage, they were able to avoid the high railroad rates between Seward and Anchorage. The railroad estimated it lost $28,000 per year to the steamships that used the port facility. The railroad management believed that closing the port would mean new revenue for the railroad. To avoid a confrontation with the steamship companies, new rates were negotiated to ease the cost of the Seward-Anchorage haul. The railroad manager, Noel Smith, closed the Ocean Dock in the fall of 1924. The dock was minimally maintained and used only in emergencies or to export large shipments of minerals. Heavy use of the dock did not occur again until World War II (Carberry 1979).

Once the Ocean Dock was closed, a new dock was needed to accommodate the smaller boats serving the inlet's communities. The Anchorage City Council and the railroad agreed to share the costs of building a new dock. The railroad completed the project in 1927; however, the city council did not approve of its construction and refused to pay its share. This facility was originally called the City Dock; later it also was known as the ARR (Alaska Railroad) dock. After World War II, the city of Anchorage, in conjunction with the Corps of Engineers, developed the Anchorage port as a commercial facility. The port, completed in 1961, has since served as a critical link for Alaska's military installations as well as its commercial interests.

Population growth in Southcentral Alaska was slow from the 1920's until World War II. In 1939 Anchorage's population was slightly more than 4,000, third in size after Juneau and Ketchikan. In less than a decade, though, its population grew to 40,000, and Anchorage became Alaska's largest city.

Several decisions made by the Federal Government in the 1930's significantly affected Anchorage's development as Alaska's major city. The Civil Aeronautics Board realized that Anchorage's location was ideal for air transport and radio communication. The

Army Corps of Engineers, in cooperation with the Alaska Railroad, mapped a 12.5-mile rail route from Portage, 47 miles south of Anchorage, to the deep-water port of Whittier, bypassing Seward. The Federal Government also expanded its role in Anchorage under New Deal programs by establishing agency headquarters there and by switching the District Court from Valdez to Anchorage (Carberry 1979).

The establishment of military bases in Anchorage in 1940 brought the first significant wave of people since the building of the railroad. Smaller communities in the region lost population as people moved into Anchorage in search of jobs. Alaska was envisioned as a vital link in the Nation's air defense system, and Elmendorf Field (now Elmendorf Air Force Base) was a major part of that system.

The next influx of people into the Anchorage area after the war came with the building of the DEW (Distance Early Warning) line radar installations from 1949 to 1958 (University of Alaska 1974). Although the actual sites were constructed all over Alaska, Anchorage was the administrative, financial, and logistics center for the project. By 1954 Anchorage was the Nation's fourth busiest air traffic operations center, earning the nickname "Crossroads of the Air World." The city's role as the State's transportation, communication, service, and financial center was becoming well established (Hill 1992).

The discovery of oil on the Kenai Peninsula in 1957, in Cook Inlet in 1966, and at Prudhoe Bay in 1968 further contributed to Anchorage's emergence as the State's economic center. Major oil corporations and support services located their headquarters there. National companies and State and Federal agencies also established offices in Anchorage.

The recent decline in the oil industry has not affected Anchorage's status as Alaska's center of commerce. The Port of Anchorage services about 85 percent of Alaska's population and is the primary link between Outside suppliers and Alaska industry and consumers. Anchorage International Airport is one of the busiest cargo airports in the nation. Equidistant from Asia, Europe, and North America, the airport services approximately 70 percent of all cargo between Pacific Asia and Europe and 95 percent of all air cargo between North America and Pacific Asia (Hill 1992).

Whittier. The city was created by the U.S. Government during World War II as a port and petroleum delivery center and as an alternate port in case Seward was destroyed by an enemy attack. The railroad spur from Portage to Whittier was completed in 1943, and the city became the primary debarkation point for cargo and troops of the Alaskan Command. Named after the poet John Greenleaf Whittier, the city is not accessible by road. The Port of Whittier remained under military control until 1960, when it was inactivated. Whittier incorporated as a second-class city in 1969.

2.2.5 Military. Alaska's strategic importance to the military was recognized early. In 1934 Alaska's congressional delegate, Anthony J. Dimond, urged the U.S. House of Representatives to defend the northern Pacific by strengthening Alaska's defensive position. However, it was not until May 1940 that the House approved the appropriations bill to construct an Army Air Corps base at Anchorage. The land where present-day Fort Richardson and Elmendorf Air Force Base are located was originally settled by homesteaders. In 1939, the land was withdrawn for military use by Executive Order. In 1940, the War Department began purchasing the homesteaders' lands and buildings. All of the homestead land had become part of the military reservation by 1943.

Alaska retained its strategic importance following World War II, and military requirements at Fort Richardson and Elmendorf Air Force Base remain high.

Fort Richardson. The installation was named for the military pioneer explorer, Brig. Gen. Wilds P. Richardson, who served three tours of duty in the territory of Alaska between 1897 and 1917. Built during 1939-41 on the site now occupied by Elmendorf AFB, Fort Richardson was established as the headquarters of the United

States Army, Alaska, in 1947. Fort Richardson was moved in 1950 to its present location on 62,000 acres of land 5 miles north of Anchorage. In 1986, the 6th Infantry Division (Light) replaced Fort Richardson's 172d Infantry Brigade, which had been the Army's defense force in the State since 1974. The 6th Infantry Division Headquarters was moved to Fort Wainwright at the time the unit was activated. Fort Richardson is now home to approximately 4,400 soldiers and 5,400 family members. In addition, 1,200 civilian employees are assigned there.

Major units based at Fort Richardson include the U.S. Army Garrison, Alaska, which supports the Army's combat forces in the State. The 1st Brigade, 6th Infantry Division (Light) is the fort's major combat unit. A fleet of helicopters assigned as part of the division's Aviation Brigade supports the 1st Brigade and other combat and combat support units.

Fort Richardson also is home to the division's two major communications battalions, the 6th Division Artillery and one of its howitzer battalions, the Noncommissioned Officer Academy, and the Light Fighter Academy, which provides light infantry and Arctic survival instruction for soldiers in Alaska.

The 6th Infantry Division (Light)'s mission is to be prepared to deploy rapidly in the Pacific theater and elsewhere, as directed, in support of contingency operations, U.S. Pacific Command objectives, and U.S. national interests. Soldiers from the 6th Infantry Division (Light) participated in the multinational task force in the Sinai in 1990 and in Operation Desert Storm in 1991.

Elmendorf Air Force Base. The Air Force was part of the Army in 1940, and Elmendorf Field was the designated airfield on Fort Richardson. The airfield was named after Capt. Hugh M. Elmendorf, a pioneer in high-altitude pursuit flying and a gunnery expert in the 1920's and early 1930's. The Air Force became a separate branch of the Armed Services in 1947, and the Army officially transferred jurisdiction of the base and its facilities to the Air Force in October 1950. A new Fort Richardson was built east of the existing military reservation.

Elmendorf is the largest Air Force installation in Alaska, sitting on 13,130 acres of land adjacent to Anchorage on the north. It is the home of the 11th Air Force, the 3rd Wing, and the 11th Air Control Wing (ACW). Assigned to the 3rd Wing are the 43rd and 54th Fighter Squadrons.

The commander of the 11th Air Force is the senior military officer in Alaska and is the military point of contact for the State. The 11th Air Force commander also commands the Alaskan Command, the Alaskan North American Aerospace Defense Command (NORAD) region and Joint Task Force-Alaska, when activated.

The mission of the 11th Air Force is to provide "Top Cover for North America" by defending North America against air attack as well as accomplishing assigned operational missions. The 11th ACW is responsible for Shemya Air Force Base (AFB), Galena and King Salmon Airports, the Alaskan NORAD Region Operations Control Center, and 17 long-range radar sites, including the Alaska portion of the North Warning System.

Approximately 6,300 active duty personnel and 10,900 family members are assigned to Elmendorf AFB. In addition, 2,425 civilians are employed on the base.

2.2.6 Demography. More than 60 percent of Alaska's population resides in Southcentral Alaska. From July 1960 to April 1990, Anchorage's population increased by 143,505 (a 173.2 percent increase), the Matanuska-Susitna Borough's by 34,495 (a 665.9 percent increase), and the Kenai Peninsula Borough's by 31,749 (a 350.7 percent increase). These boroughs represent three of the five fastest growing areas in Alaska. The Matanuska-Susitna Borough was the fastest-growing area during the past decade, increasing by 112.7 percent, from 17,816 in 1980 to 39,683 in 1990. Table 2-6 shows the population from 1960 to 1990 by borough and census area.

TABLE 2-6.--*Borough and census area population, 1960-1990*

	1960	1970	1980	1990
Anchorage	82,833	126,835	164,431	226,338
Matanuska-Susitna	5,188	6,509	17,816	39,683
Kenai Peninsula	9,053	16,856	25,282	40,802
Valdez-Cordova	4,603	4,977	8,348	9,952

According to the 1990 census, the Municipality of Anchorage has a population of 226,338, or 41 percent of the State's population. The Kenai Peninsula Borough has the second largest population in the Southcentral region with 40,802, followed by the Matanuska-Susitna Borough with 39,683 and the Valdez-Cordova census area with 9,952. Figure 2-14 shows the population in Alaska by labor market region from 1960 to 1990.

More Alaska Natives now live in Anchorage (14,569) than in any other borough or census area in the State. The greatest increase occurred in the Anchorage/Matanuska-Susitna region, which had 15 percent of the Alaska Natives in 1980 and 19.3 percent in 1990.

The population in Alaska overall is younger than the national average. The median age in the United States in 1989 was 31.5 for males and 33.8 for females. In Alaska, the 1990 median age was 28.5 for males and 28.4 for females.

Armed Forces personnel in Alaska have played a significant role in the State's population growth. Currently, the military population, including family members, accounts for 10.5 percent of the State's population. The majority are assigned to Elmendorf AFB and Fort Richardson, both in the Municipality of Anchorage.

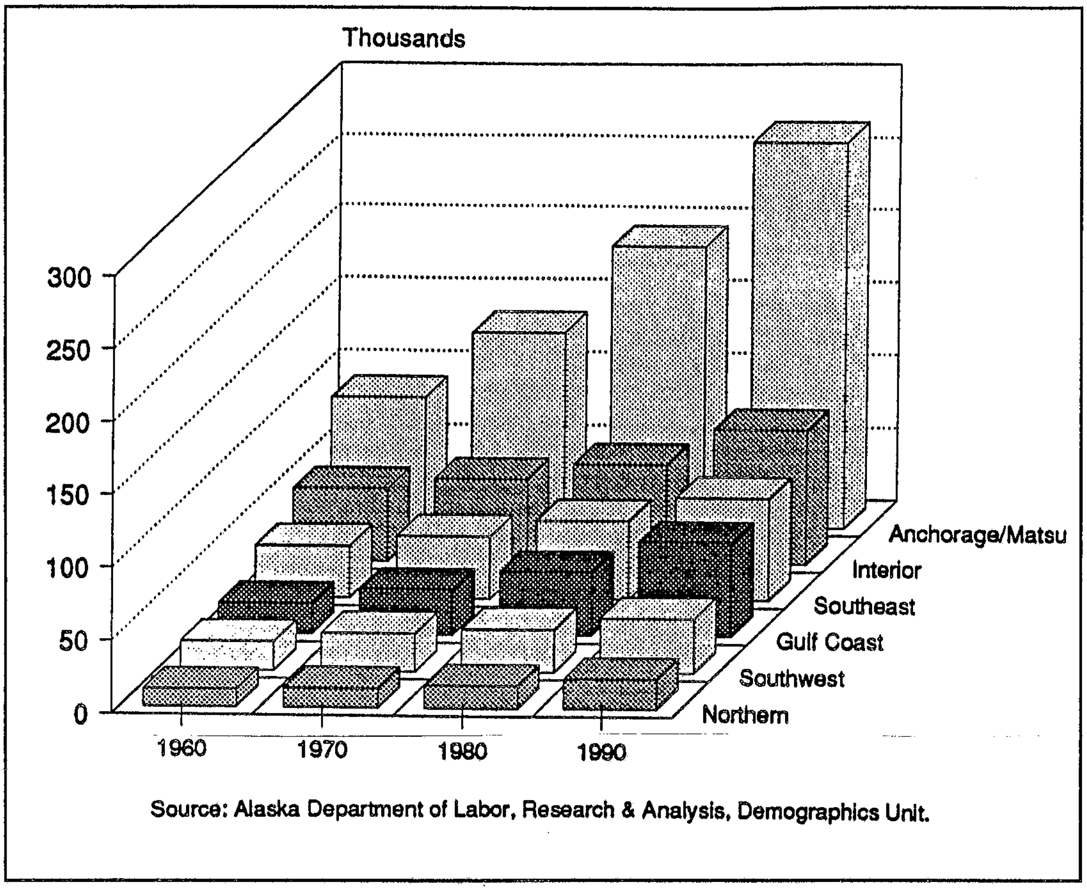

FIGURE 2-14.--Alaska population by labor market region, 1960-90.

2.3 Ports of Southcentral Alaska

The ports and harbors in the Cook Inlet area are described in this subsection. Locations of the ports (except Valdez, which is off the map to the right) are shown in figure 2-15. Table 2-7 lists the distances from the major Southcentral Alaska ports to Anchorage and to Seattle, Washington. Information on the ports was taken from the Peratrovich, Nottingham & Drage, Inc., study for the Alaska Department of Commerce and Economic Development, dated January 1993 (see References) unless otherwise noted.

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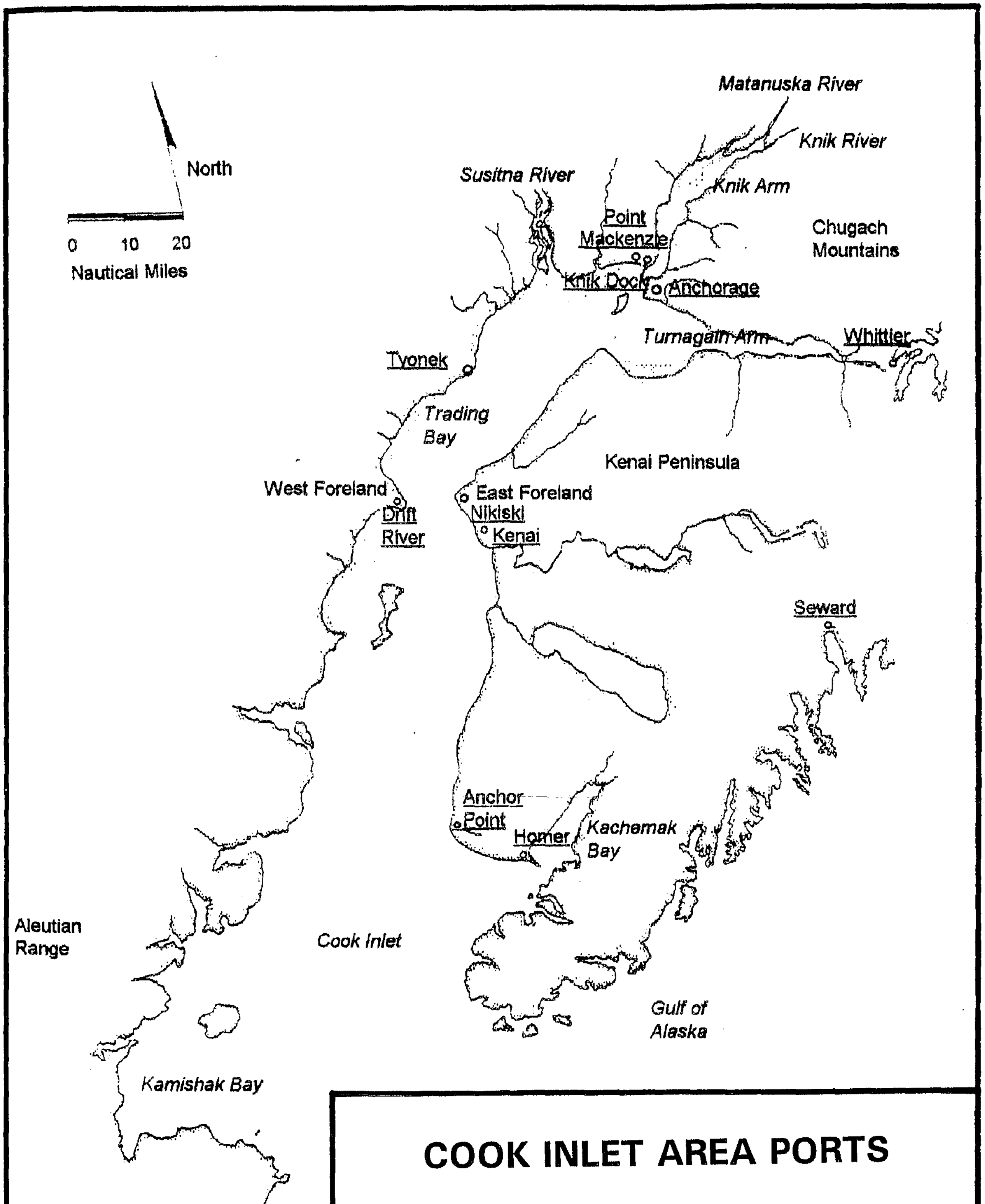

COOK INLET AREA PORTS

US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

2-15

TABLE 2-7.--*Distance from major Southcentral Alaska ports to Anchorage and Seattle*

Port	Anchorage (nautical miles)	Seattle (nautical miles)
Homer	143	1,313
Seward	274	1,234
Valdez	385	1,234
Whittier	367	1,241
Anchorage	-	1,428

2.3.1 Homer. The Port of Homer is located on the southern Kenai Peninsula in lower Cook Inlet at the head of Kachemak Bay, approximately 230 miles by road or 143 nautical miles from Anchorage. The port has a 60-acre small boat harbor, one deep-water dock, two shallow-draft piers, 30 acres of staging area, cold storage, gear storage, and a 40-ton steel vessel grid.

The Homer deep-water cargo dock is located at the southeast end of the small boat harbor. Completed in 1990, the L-shaped dock extends 600 feet into Kachemak Bay and 340 feet parallel to shore, providing berthing space for three vessels. Fuel is available by truck; water and sewer are scheduled to be extended to the dock by spring 1993.

The Homer city pier is owned by the city of Homer and jointly operated by the city, Chevron USA, Inc., the U.S. Coast Guard, and the State of Alaska. Located at the distal end of the spit, the pier extends 410 feet offshore with alongside depths extending to -30 feet MLLW at the outer face. The southeast face has alongside depths to -12 feet MLLW; the northwest face, primarily used for mooring a Coast Guard cutter, has alongside depths to -13 feet MLLW. The pier also is used to receive general cargo and petroleum products and as a ferry terminal by the Alaska Marine Highway System.

Facilities at the pier include a half-ton crane and a pipeline extending from the pier to a tank farm with a total capacity of 732,000 barrels. Fuel and utilities also are available.

The Homer small boat harbor was constructed by the Corps of Engineers in 1962. The Corps restored the breakwater and basin after they were severely damaged by the 1964 earthquake. In 1985 the Corps completed expansion of the 16.5-acre harbor to 50 acres. The harbor has 740 slips and approximately 4,000 linear feet of transient space. The harbor is home to 400 vessels; however, use increases to 2,000 during the summer. Harbor basin depth varies from -14 to -20 feet MLLW at the southeast end to -10 to -15 feet MLLW at the northwest end. Controlling channel depth is -14 feet MLLW. Two floating piers provide gasoline, diesel fuel, and water. Facilities include a launching ramp and two grids, one 100 feet and the other 168 feet.

The fish dock is owned by the city of Homer and operated by Seward Fisheries, a division of Icicle Seafoods, Inc., and Alaska Sea Venture. Located on the east side of the small boat harbor, the dock is used to receive and handle fish. Its 383-foot face has alongside depths to -20 feet MLLW. Ten cranes are available: two 5-ton, six 2 1/2-ton, and two 60-ton mobile cranes. A pneumatic-augered ice facility produces up 100 tons of ice per day and can deliver 30 tons per hour directly onto ships. Storage facilities can store up to 250 tons.

2.3.2 Kenai. The Port of Kenai is located on the north side of the Kenai River, 11 miles north of Cape Kasilof. It is approximately 160 road miles or 60 nautical miles from Anchorage. The city of Kenai owns and operates the 170-foot-long Kenai public dock. Alongside depths extend to -2 feet MLLW in the Kenai River.

Three 8-ton-capacity cranes are used mainly to load and unload fish. Facilities at this port include a 500,000-square-foot staging area, two concrete boat ramps, and a 50-ton tidal grid with capacity for boats up to 40 feet long. Gasoline, diesel fuel, and water also are available.

2.3.3 Nikiski. The Port of Nikiski, 8.5 miles north of Kenai, has three medium-draft piers and two shallow-draft wharves.

The Collier pier at Nikiski is owned and operated by the Union Chemical division of Union Oil Company of California. Located 3.3 miles south of the East Foreland, the T-head pier is 228 feet long at the face and 60 feet long on the ends. It provides alongside depths to -40 feet MLLW and 1,135 feet of berthing space, including dolphins. The pier is primarily used to ship anhydrous ammonia and dry bulk urea and to receive sulfuric acid, caustic soda, and petroleum products. Equipment includes a bulk urea loading tower, three unused swivel-joint loading arms, and three stiff-leg derricks. The loading tower has a telescoping loading spout with a capacity of 1,000 tons per hour and is served by a 48-inch electric belt-conveyor system extending from a covered, 125,000-ton- capacity storage system. The capacity of the derricks ranges from 10 to 20 tons. The pier is accessible by gravel road from Kenai Road.

The Phillips 66 pier, just north of the Collier pier, is owned by the Kenai LNG Corporation. Operated by Phillips Petroleum Company and Tesoro Alaska Petroleum Company, the T-head pier has a 100-foot face and provides 1,050 feet of berthing space. The alongside depth extends to -40 feet MLLW. The pier is mainly used to ship liquefied natural gas and petroleum products and to receive crude oil.

The Kenai Pipeline Company pier is owned by the firm of the same name, which operates it in conjunction with Chevron U.S.A., Inc., and Tesoro Alaska Petroleum Company. Located just north of the Phillips 66 pier, the T-head pier has a 348-foot face that provides 1,310 feet of berthing space, including dolphins. Alongside depth extends to -42 feet MLLW. The pier is primarily used to receive crude oil and ship petroleum. Four pipelines varying from 14 to 24 inches in diameter are used to transport petroleum products to and from the three storage tanks, which range in capacity from 323,000 to 800,000 barrels.

The Rig Tender's dock, also called Port Nikiski dock, is a shallow draft wharf 2.1 miles south of East Foreland, just north of the Kenai Pipeline Company pier. Crowley Maritime Corporation and Tesoro Alaska Petroleum own and operate the wharf, which has a 600-foot face and is 450 feet long at both ends. The depths alongside vary from --10 to -14 feet MLLW on the face to 0 to -14 feet MLLW on the south side; the north side goes dry at low tide. Handling facilities include three crawler-type cranes with capacities up to 150 tons, two 10-ton diesel forklifts, two 4-ton gasoline forklifts, and one 3-ton gasoline forklift. The wharf is used primarily to ship petroleum products. Warehousing facilities include a 7-acre terminal that serves the offshore oil-drilling industry and storage tanks with a 510,000-barrel capacity connected to the wharf by a pipeline. Utilities include five fuel and water stations that transfer up to 1,000 gallons per minute, and 110/440-volt electricity. A heliport is adjacent to the terminal; the facility also is accessible by gravel road from North Kenai Road.

Arness Landing, 2.5 miles northeast of East Foreland, is constructed from three grounded Liberty ships surrounded by a sheet-pile bulkhead with a gravel surface. The grounded ships provide 3,000 feet of berthing space, most of which is exposed at low water. Barges supporting offshore drilling operations used the facility for handling neo-bulk and dry-bulk cargo, primarily cement and drilling mud. The facility has been inactive since 1976 (Alaska Transportation Consultants, Inc. 1985).

2.3.4 Drift River. The Drift River marine terminal is located in the vicinity of West Foreland, across Cook Inlet from Kenai and Nikiski, southwest of the village of Tyonek. The facility consists of the offshore Christy Lee loading platform, which is used for shipment of crude oil. The platform is equipped with breasting and mooring dolphins designed to accommodate tankers in the 150,000 deadweight-ton (dwt) class. Alongside depth is 60 feet. The offshore platform is connected to a shoreside tank farm by two 30-inch crude pipelines. Tankers can be loaded at a rate of 50,000 barrels per hour. Access to Drift River is either by helicopter or via the marine terminal (Alaska Transportation Consultants, Inc., 1985).

2.3.5 Tyonek. The Port of Tyonek is located on the North Foreland, 1.5 miles north of Tyonek Village. The 1,466-foot-long, T-head, bulk-loading facility is the Beluga Coal Company's preferred site for a coal port. The 174-foot dock face once had alongside depths to -34 feet MLLW; however, recent measurements indicate shoaling as high as 0 feet MLLW.

2.3.6 Anchorage. The Port of Anchorage, shown in figure 2-16, is a deep draft port in upper Cook Inlet on the southeast side of Knik Arm. Located in Anchorage, the State's largest city, the port is Alaska's major seaport and the main port of entry into the Southcentral and Interior regions. It is 1,428 nautical miles from Seattle, Washington. Facilities include deep draft wharves, petroleum terminal docks, commercial barge warehouses, and a small boat haul-out. Tugs are available with prior arrangement.

Facilities owned by the Municipality and Port of Anchorage, and generally operated by port users, include two petroleum and three general cargo berths. The approaches to the Port of Anchorage are dredged to an elevation of -35 feet MLLW annually, as indicated in figure 2-17.

The first petroleum berth, POL Number 1, is owned by the municipality and operated by the Port of Anchorage. It is an offshore wharf 612 feet long, including dolphins. The dock is primarily used to receive petroleum products and bunker vessels; however, occasionally it is used to receive general cargo shipments.

POL Number 2 is a new T-head dock just south of the main pier. (See figure 2-16.) This berth is primarily used to unload refined petroleum products. It is equipped with a hose tower with four 8-inch petroleum hoses supported by tide-compensating reels. Each hose has a 2,000-barrel-per-hour pumping rate.

General cargo berth Number 1 is a 1,600-foot-long pier used mainly for break-bulk cargo; however, it also has the capability to handle roll on/roll off (Ro/Ro) cargo. A

FIGURE 2-16.--Port of Anchorage. This photo was taken in the summer of 1992.

27,000-square-foot heated transient shed is located on the pier and is accessible by truck and rail.

The 610-foot-long general cargo berth Number 2 is used primarily for lift on/lift off container operations. It also has the capability to handle Ro/Ro and break-bulk cargo.

General cargo berth Number 3 is 994 feet long, including a single dolphin. It is primarily used for Ro/Ro operations; however, it also has container and break-bulk capabilities.

Cargo handling equipment at the Port of Anchorage includes three level-luffing, rail-mounted, diesel electric gantry cranes. Two of them have primary capacities of 40 tons with 5-ton auxiliary hoists; the third has a 7.5-ton capacity. The port also has two 28-ton rail-mounted electric Paceco container cranes and a 40-ton rail-mounted electric Mitsubishi container crane. Portable cranes with 150-ton capacity and 30-ton-capacity forklifts are available. In addition, the port has two privately owned, 8-inch-diameter bulk cement lines.

Thirty-eight acres of public cargo transit area are located next to the wharf in the 110-acre port industrial park. The wharf has fresh water, telephones, and contracted fuel, sewer, and garbage service available. Four gangs of stevedores are available on 4 hours' notice; up to 10 gangs are available with 12 hours' notice.

The Municipality of Anchorage gained title from the State of Alaska to 1,300 acres of tidelands extending about 4 miles north of its existing port facilities in January 1993. The mayor of Anchorage has indicated that these "north tidelands" may be developed as export facilities for timber products and coal. Port of Anchorage officials have begun negotiations with commercial interests in the timber and coal industries for planning the port expansion. This development would compete with

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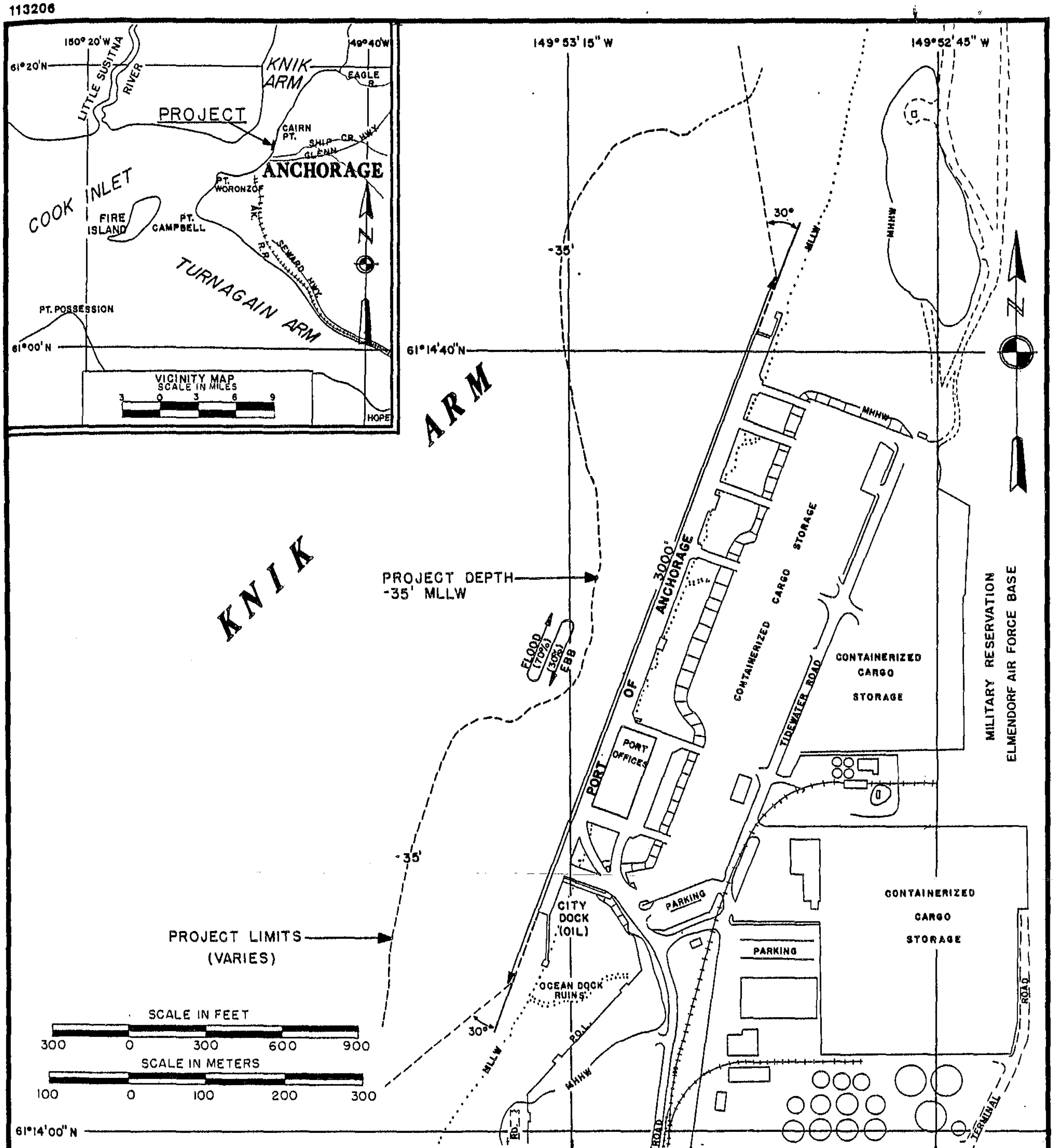

ANCHORAGE HARBOR

US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

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proposed timber and coal port facility across Knik Arm on land owned by the Matanuska- Susitna Borough.

The Alaska Railroad Corporation owns the waterfront south of the Port of Anchorage. The Municipality of Anchorage leases the tidelands from the bulkhead line to -45 feet MLLW, and various firms lease the uplands.

The Lone Star Cement Anchorage terminal is located directly east of general cargo berth Number 1 and 300 yards south of POL Number 2. Alaska Basic Industries operates the two bulk-cement facilities, which are connected by pipeline to the Anchorage docks. At the waterfront site, a grounded 250-foot landing ship, which goes dry at low tide, has been used to receive cement by barge.

The Chugach Electric Association Marine Division dock is 100 feet south of the Lone Star terminal. Chugach leases the dock from the Alaska Railroad. Operated by Pickworth and Associates, Inc., the dock provides 290 feet of berthing space, which goes dry at low tide. Handling equipment includes cranes with capacities up to 53 tons and three forklifts. Five acres of open storage is available.

The North Star Terminal and Stevedore Company owns and operates the Anderson dock facility, 400 yards south of the Chugach Electric dock. The dock, with a 350-foot face, goes dry at low tide. It is used to receive and ship general cargo, containers, and heavy lift equipment by barge. The berth is dredged by dozers on an ongoing basis. The railroad spur to the dock is used to load shipments to and from railcars. Cranes with capacities up to 150 tons are available. Ten thousand square feet of covered storage and 13 acres of open storage are available. A permit from the Corps of Engineers will allow North Star to fill out to 0.0 feet MLLW, which will add more than 8 acres of storage and develop a new 8-foot breasting face.

The Minch dock is located just south of the Anderson dock. Owned and operated by Douglas Management, Inc., the 360-foot bulkhead, which goes dry at low tide, is used for modular buildings, bulk salt, equipment, and general cargo unloading. Twelve acres of open storage and cranes with capacities up to 150 tons are available. Douglas Management has applied for a Corps of Engineers permit to extend the filled area to 0.0 feet MLLW to add more than 4 acres of open storage area.

The Whitney Fidalgo Anchorage dock is on the north side of Ship Creek, 900 feet above the mouth. Owned and operated by Kyokuyo USA, Inc., the dock is used to receive fish and seafood. It has 212 feet of docking space and goes dry at low tide.

The site of the old small boat facility is 200 yards upstream of the Whitney Fidalgo Anchorage dock. It returned to Alaska Railroad ownership with the construction of a new facility at Ship Creek Point. A 90-foot pier and a few tie-up spots used by transit boats still exist.

The Port of Anchorage developed a recreational boating facility 300 yards south of the mouth of Ship Creek between 1986 and 1989. The municipality owns and operates the boat launch, a 50-foot interim maritime dock, and a staging area on a 5.35-acre site leased from the Alaska Railroad. The remainder of the developed and undeveloped land was transferred back to the Alaska Railroad.

The Alaska Railroad Company and LoPatin Company entered into an agreement in early 1992 to develop an area including the waterfront south of the mouth of Ship Creek and the Ship Creek basin up to the Chugach dam (excluding the municipality lease mentioned above). This development will not include marine or industrial uses.

2.3.7 Knik Dock. Knik Dock is located on the western side of Knik Arm, approximately 2-1/2 air miles north of Anchorage. It has a 333-foot face and is equipped with a 25-ton crawler crane, a D-8 Caterpillar, a wheel loader with forklifts, a 12-cubic-yard end dump, a 15-ton forklift, a John Deere 450 dozer and a John Deere crawler loader. A tug is on call 24 hours a day. Storage facilities include 25 acres of private staging area and 3,600 square feet of dry heated storage. The dock has water, fuel, and power available.

2.3.8 Port MacKenzie. The Matanuska-Susitna Borough has been planning a port development across Knik Arm from the Port of Anchorage since before 1981. Borough land is available at this site, and a Corps of Engineers permit has been approved for construction of a piling-supported trestle. The trestle would cost around $17 million to construct. The planned port's location is shown in figure 2-15, and a drawing is in figure 2-18.

The facility is intended primarily for export of coal mined from the Wishbone Hill prospect and other prospective Matanuska and Susitna Valley coal mines. Development rights for Wishbone Hill coal are now in the hands of a large Japanese energy company. Coal exports could exceed 3 million tons per year, depending on the future international market.

The borough is also negotiating with a Japanese-owned company to use the planned facility for import of iron ore pellets from various Pacific Rim sources to a reduction plant proposed for construction on borough land near the port. This plant would export pig iron briquettes to overseas refineries, possibly in Europe via the Northern Sea Route across the Arctic Ocean. The iron ore reduction plant could import up to 1.8 million tons of ore pellets per year and export up to 1.2 million tons of iron briquettes per year.

The borough is consulting with Canadian coal port specialists for operation of the port. The port site in now accessible by a dirt road, which would be improved in the early stages of development. A 30-mile railroad spur, which could cost as much as $50 million, would eventually be required for higher throughputs of coal. Construction

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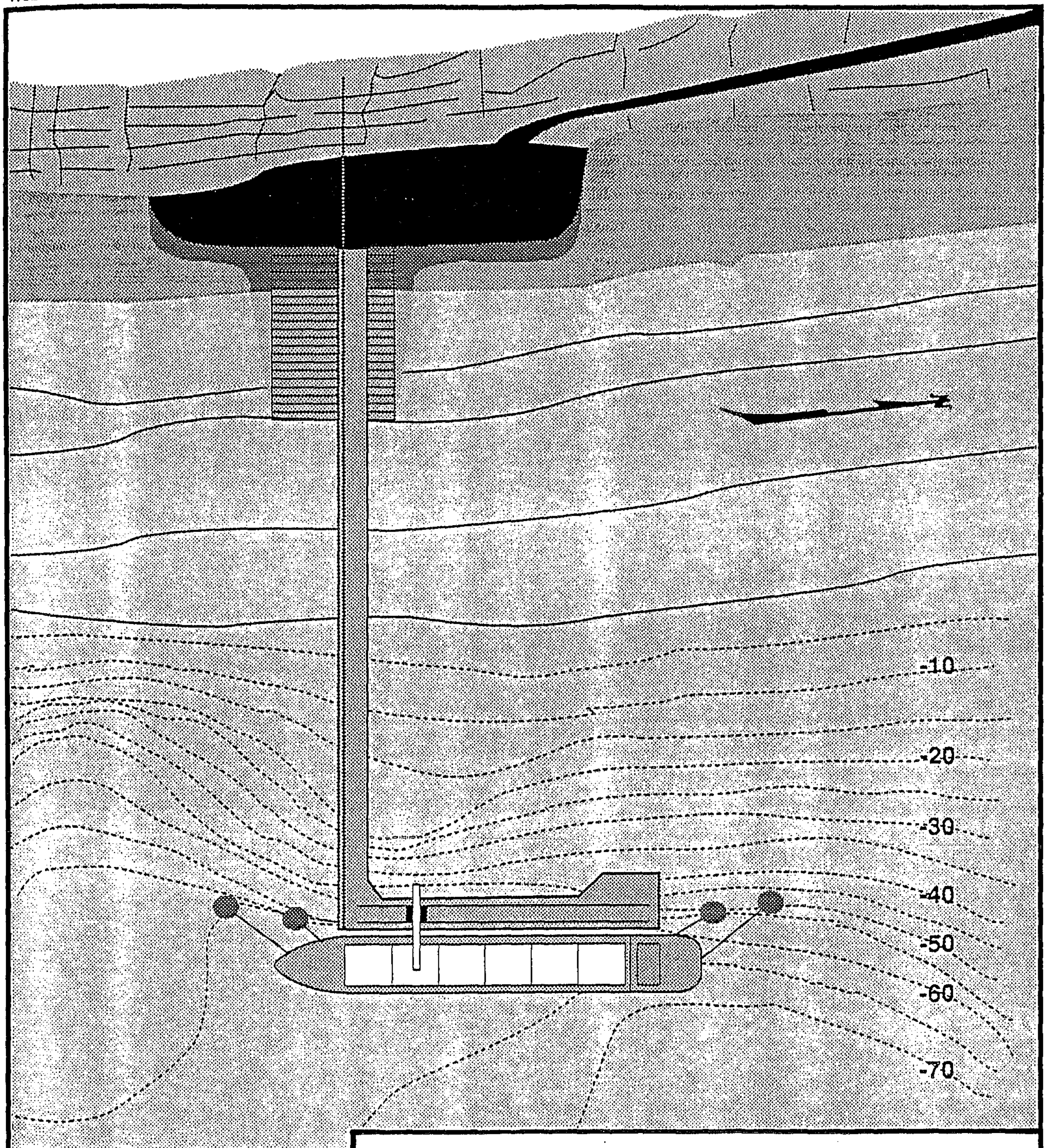

PROPOSED PORT MACKENZIE

US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

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of Port MacKenzie could begin as soon as 1995, though financing arrangements are not yet certain.

2.3.9 Whittier. Whittier is located near the head of Passage Canal on the northwest side of Prince William Sound, 367 nautical miles from Anchorage. The port is 63 miles by rail from Anchorage and 65 miles by rail from Seward, and serves as a principal terminus for the Alaska Railroad. No road access is available to Whittier.

The port has two medium draft piers, one railroad car barge facility, a ferry dock and a small boat harbor. The DeLong pier is a fuel pier owned and operated by the U.S. Army. The 425-foot-long pier has an alongside depth to -45 feet MLLW. Two 12-inch pipelines on the pier split into four 12-inch pipelines that extend to 13 storage tanks with a total capacity of 650,000 barrels.

The Alaska Railroad wharf is located 550 yards west-southwest of DeLong pier. Owned and operated by the Alaska Railroad, the wharf extends 1,000 feet into Passage Canal and provides alongside depths to -30 to -40 MLLW. The dock has limited load capacity because of deterioration. One track is inside and one track is at the rear of a 43,000-square-foot transit shed. Water and electricity are available on the dock.

The Whittier ferry terminal, owned and operated by the State, is 100 yards northwest of the Alaska Railroad wharf. The terminal provides 200 feet of berthing space with a depth alongside of -18 feet MLLW.

The 19.2-acre small boat harbor is owned by the State and operated by the city of Whittier. Located one-quarter mile west of the ferry terminal, the 2,180-foot, L-shaped, rubblemound breakwater with a 225-foot sheet- pile extension provides protected water for 332 slips, ranging in length from 24 to 28 feet. A 260-foot float accommodates 20 to 30 transient vessels. During summer months, 150 to 200 transient vessels use the float, rafting 10 to 12 vessels deep. This creates significant congestion and maneuverability problems because the transient float is near the harbor entrance. The harbor has two launching buoys to accommodate trailers, two small boat grids, and a 30-ton mobile vertical boat lift. The Alaska District Corps of Engineers has a study under way to address the problems of mooring small boats at Whittier.

The city of Whittier owns and operates the city dock, located at the southwest corner of the small boat harbor. The dock provides a total breasting distance of 82 feet and a depth alongside to -20 feet MLLW. The dock is used as a runway for a 30-ton diesel hydraulic mobile boat lift and for handling supplies and equipment. The Alaska Railroad services the automobile and boat trailer transfer ramp at the rear of the dock. The dock can be reached by a gravel road from the automobile and boat trailer transfer ramp. Water and electricity are available on the dock.

2.3.10 Seward. The Port of Seward is located at the head of Resurrection Bay on the Gulf of Alaska side of the Kenai Peninsula. Seward, approximately 126 road miles or 274 nautical miles from Anchorage, serves as the terminus for both the Alaska Railroad and the Seward Highway.

Harbor facilities at Seward include a small boat harbor, nine docks, and approximately 400 acres of staging area. At least three working tugs are available 24 hours per day.

The three faces of the Alaska Railroad terminal and port facility provide 1,250 feet of berthing space. Two of the faces, 450 and 600 feet long, have alongside depths to -35 feet MLLW; the third, a 200-foot-long face, has alongside depths to -38 feet MLLW. Cargo handling equipment includes cranes with 140-ton capacities and forklifts with 30-ton carrying capacities. A 24,000-square-foot heated warehouse is located on the dock. Diesel fuel is pumped out of the west berth; gasoline is delivered by truck.

The coal terminal dock, a dry-bulk shipper used primarily for coal, has a capacity of 1,000 tons per hour. Located between the Alaska Railroad terminal and the small boat harbor breakwater, the dock's mooring basin has water depths to -58 feet MLLW.

The Seward small boat harbor is owned by the State of Alaska and operated by the city of Seward. Located .25 mile west of the Alaska Railroad dock, the harbor has 400 slips, including transient vessel space and a seaplane float. The harbor depth is -12 feet MLLW, and the channel depth is -11 feet MLLW. Facilities include a grid, a 50-ton boat lift, and a launching ramp. Gasoline, electricity, and diesel fuel are available year-round. The small boat harbor is chronically overcrowded in summer. The Corps has a study under way to address the problems of mooring small boats at Seward.

The municipal and city piers and the Seward Fisheries wharf provide 1,000 feet of combined berthing space at the north end of the small boat harbor. The city pier and Seward Fisheries wharf have alongside depths of -13 feet MLLW; the municipal pier provides alongside depths of -15 feet MLLW. The docks are used primarily by fishing vessels and Seward Fisheries. The municipal dock has a 50-ton boat lift. The city pier has a 2-1/2-ton electric-hydraulic mast and boom derrick with a 30-foot knuckle boom. The Seward Fisheries wharf has two 2-1/2-ton electric-hydraulic mast and boom derricks with 30-foot booms, a 12-inch suction pipeline used to transfer fish from boats to the processing plant at the rear of the wharf, and 15 gas forklifts with capacities of 1 to 3 tons.

The Alaska State Ferry uses the Fourth Avenue city dock, 1 mile south of the small boat harbor. The dock is owned by the city of Seward and operated by the Alaska Marine Highway System and Northern Stevedoring and Handling Corporation. It has 200 feet of docking space and alongside depths to -35 feet MLLW. Three diesel mobile cranes are available with 140-, 35-, and 20-ton capacities and 110-, 70-, and 45-foot booms, respectively. A 90-ton diesel crawler crane with an 80-foot boom for transferring cargo also is available.

The University of Alaska Fairbanks' Institute of Marine Science (IMS) owns and operates the wharf one mile west of the Fourth Avenue city dock. This wharf provides 150 feet of berthing space and alongside depths to -40 feet MLLW. The IMS dock has fuel, electricity, and a 5-ton gasoline mobile crane with a 16-foot boom. The 133-foot R/V *Alpha Helix,* a research ship owned by the National Science Foundation and operated by IMS, is moored at the IMS dock.

Seward Marine Services, Inc., owns and operates the 18-1/2-foot-high, 250-foot-long dock 900 feet south-southwest of the IMS wharf. The dock, which has depths to -14 feet MLLW, is used primarily to receive herring.

2.3.11 Valdez. The Port of Valdez is located at the head of Prince William Sound on Port Valdez Inlet. It is the southern terminus of the Trans-Alaska Pipeline and the Richardson Highway, and is 304 road miles or 385 nautical miles from Anchorage. With the construction of the Trans-Alaska Pipeline in 1977, Valdez became the Nation's first superport, shipping 55 million tons of crude oil per year (Alaska Consultants, Inc., 1981).

Valdez is an ice-free port with five deep draft docks, several medium and shallow draft docks, a small boat harbor, several commercial barge facilities, and a four-berth crude oil shipment terminal. It can accommodate all cargo handling except dry bulk.

Owned by the city of Valdez, the city dock is a 600-foot-long wood-pile dock with alongside water depths to -26 feet MLLW.

The Valdez Dock Company owns and operates the Valdez Petroleum dock, 400 feet east of the city dock. The 200-foot timber-pile, T-head dock has 300 feet of berthing space with dolphins at both ends and alongside depths of -24 feet to -34 feet MLLW. Eight product pipelines up to 8 inches in diameter extend from the wharf to the storage tanks, which have a total capacity of 180,500 barrels.

The State of Alaska owns and operates the Alaska State Ferry terminal. Located west of the city dock, it provides 200 feet of berthing space and alongside depths of -20 feet MLLW.

The Valdez small boat harbor has 600 slips plus transient space available. The harbor and entrance channel have depths to -9 feet MLLW, with a mid-channel depth to -12 feet MLLW. Located east of the fuel pier, the harbor has boat launching ramps, a 65-ton mobile vertical boat lift, a 150-ton grid, and the 150-foot Fisherman's dock with 2- and 5-ton cranes.

The Port of Valdez general cargo and container wharf is 1-1/2 miles east of the small boat harbor. Owned and operated by the City of Valdez, the 704-foot floating dock has 1,200 feet of total berthing space including dolphins. Alongside depths are to -65 feet MLLW. The city container terminal has 21 acres of lighted, direct open storage, 1,000 acres of remote open storage, nine 522,000-barrel-capacity grain silos, two 125-ton crawler cranes, three 30-ton forklifts and 3- and 10-ton forklifts.

Two infrequently used barge docks are located at the old townsite. The Northwest dock, jointly owned and operated by Puget Sound Tug & Barge Company, Alaska Hydro-Train Company, and Tesoro Alaska Petroleum, is a backfilled timber bulkhead marginal wharf. It has 325 feet of berthing space along the wharf and 200 feet of berthing space for railcar barges. Alongside depths are -5 feet MLLW. Facilities include two 8-inch product pipelines and a railcar transfer bridge.

Valdez Alaska Terminals, Inc., owns and operates the other barge facility. Built from a backfilled grounded barge, it provides 228 feet of space along the wharf with alongside depths of -5 feet MLLW. Approximately 10 acres of upland staging area are available.

Alyeska Pipeline Service Company owns and operates the Valdez Marine Terminal, terminus of the Trans-Alaska Pipeline. Four deep draft berths are available for shipment of crude oil. Berth Number 1 is 1,200 feet long including dolphins and has alongside depths of -150 feet MLLW. Berths 3, 4, and 5 are T-head piers, each with four 16-inch loading arms. Berth Number 3 is 1,050 feet long including dolphins and has alongside water depths of -150 feet MLLW. Berth Number 4 is 1,380 feet long including dolphins and has an alongside water depth of -90 feet MLLW. Berth Number 5 is 1,385 feet long including dolphins with alongside water depths of -55 feet MLLW. Three 5,750-horsepower tugs and two mooring launches are available for docking and undocking. One 9,000-horsepower tug can be used for towing.

2.4 Waterborne Commerce of Southcentral Alaska

2.4.1 General. The waterborne commerce of Southcentral Alaska is constrained by demand for imports to and exports from the region and by the physical limitations of the port facilities, which were reviewed in the previous section. Port operations are further constrained by limitations of the road and rail links which connect the ports with the hinterland resources or markets. The State-funded "Southcentral Ports Development Project," (Peratrovich, Nottingham and Drage 1993) summarizes conditions of Southcentral Alaska roads and railways and the historical throughput of ports in the region. Historical waterborne commerce statistics for Southcentral ports other than the Port of Anchorage are shown in tables 2-8 to 2-10. A discussion of Port of Anchorage historical data and trends follows.

2.4.2 Port of Anchorage - Historical Commodity Movements. Prior to 1964, freight was moved throughout Southcentral Alaska by train from deep-water ports at Seward and Whittier. Steamship lines brought general cargo to Seward, where it was transferred to railcars and moved to the population centers at Anchorage, Palmer, and Fairbanks. From Seward, this involved a rail movement of about 125 miles to Anchorage, and 365 miles to Fairbanks. The 125-mile section between Seward and Anchorage includes some of the steepest grades and traverses some of the most difficult

TABLE 2-8.--*Waterborne freight, ports of Whittier, Seward, Homer, and Cordova, 1975-90 (tons)*

	Whittier	Seward	Homer	Cordova
1975	NA	382,051	39,279	NA
1976	NA	236,722	30,761	NA
1977	414,054	89,449	118,570	35,219
1978	333,673	92,554	156,530	92,554
1979	257,417	59,754	184,093	55,955
1980	317,984	137,849	158,673	27,001
1981	380,974	113,002	156,293	30,893
1982	385,065	137,118	52,964	28,384
1983	358,903	40,748	134,006	31,654
1984	NA	356,612	309,227	28,455
1985	NA	872,825	147,585	16,598
1986	NA	811,951	73,707	19,377
1987	298,194	939,938	45,892	16,217
1988	352,895	919,700	66,373	39,216
1989	NA	703,372	242,983	53,380
1990	NA	NA	NA	NA

TABLE 2-9.--*Waterborne freight details, Port of Seward, 1989 (tons)*

	Inbound	Outbound	Total
Seafood products	-	15,757	15,757
Coal	-	585,931	585,931
Logs & lumber	2,250	45,765	48,015
Pipe	36,342	-	-
Fabricated metal products	563	-	563
Machinery & equipment	1,948	4,052	6,000
Nitrogenous chemical fertilizers	-	5,510	5,510
Commodities	2,527	2,727	5,254
Total	43,630	659,742	703,372

TABLE 2-10.--*Waterborne freight, Port of Valdez, 1983-91*

Year	Tons
1983	5,000
1984	40,000
1985	38,000
1986	5,000
1987	13,000
1988	19,968
1989	127,460
1990	23,567
1991	21,302

Source: City of Valdez for years 1988 through 1991. All other years from Corps of Engineers.

terrain found on the Alaska Railroad system. Freight which required specialized handling, such as heavy machinery, pipes, and vehicles, was carried to Whittier by rail barge or train-ship and moved by the Alaska Railroad to major population centers.

Following the Good Friday earthquake of 1964, the Port of Anchorage emerged as the only major operable shipping facility in the region. As a result, major changes took place in waterborne transportation in Alaska and the railbelt area in particular. The outmoded steamship service to Seward was replaced by a modern fleet equipped to deliver containerized general freight to the developing Port of Anchorage. Freight could then be distributed by rail or truck to local business or to cities in the railbelt area. General cargo tonnage through the port of Anchorage increased from 398,000 tons in 1970 to 1,175,000 tons in 1980.

Table 2-11 shows historical cargo through the Port of Anchorage. From 1987 through 1991, containers and trailer-van traffic averaged 59.5 percent of total throughput, petroleum traffic averaged 36.8 percent, and bulk commodities averaged 3.7 percent. Containerized cargo and bulk petroleum accounted for nearly all of the total tonnage at

Anchorage in 1991. Of the 1,318,000 tons of containerized cargo handled in 1991, a little more than 1,200,000 tons were inbound, or about 91 percent.

The decline in petroleum shipments during the early 1980's was due to the completion and use of a pipeline from the refinery at Nikiski to Anchorage. Petroleum shipments through the port have increased rapidly in recent years, from about 300,000 tons in 1982 to 925,000 tons in 1991. Just under 40 percent of petroleum tonnage in 1991 was inbound. Total cargo increased from 1,767,000 tons in 1982 to nearly 2,313,000 tons in 1991, an increase of about 31 percent, or an annual increase of about 2.7 percent.

TABLE 2-11.--*Historical commodity flows, Port of Anchorage, 1980-91 (tons)*

Commodity	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Freight	2,764	6,395	22,128	15,812	33,937	9,222	1,826	903	891	148	896	327
Cement	18,836	32,497	63,340	46,378	48,599	87,927	70,149	57,312	48,328	66,103	76,101	63,164
Coal	27,754	0	0	0	0	0	0	0	0	0	0	0
Insulation	1	1	0	0	0	0	0	0	0	0	0	0
Iron or steel	10,633	25,373	30,292	59,578	53,940	23,604	9,026	348	28	121	1	0
Lumber	355	2,279	14,316	26,570	13,899	1,726	65	0	6,727	2,873	14	25
Petroleum, NOS	3,021	2,166	3,929	3,831	5,399	6,272	3,084	271	1,684	1,189	747	2,358
Transshipped cargo	38,390	27,115	36,855	27,337	38,148	37,786	10,191	14,821	10,933	8,560	0	272
Vans, flats, containers	1,043,004	1,154,060	1,253,190	1,390,396	1,238,497	1,194,846	1,138,143	1,152,611	1,133,461	1,263,008	1,324,262	1,318,940
Vehicles	29,414	39,829	37,626	42,460	15,803	2,664	1,934	1,879	2,037	2,288	2,262	1,467
Petroleum, bulk	589,580	365,997	304,914	394,576	684,139	561,151	385,995	514,564	701,484	963,570	791,193	925,173
TOTAL	1,763,752	1,655,712	1,766,590	2,006,938	2,132,361	1,925,198	1,620,413	1,742,709	1,905,573	2,307,860	2,195,476	2,311,726

NOS = Not otherwise specified.

3. PROBLEM IDENTIFICATION

3.1 Deep Draft Navigation in Lower Cook Inlet

The ports of Southcentral Alaska, including all deep draft ports of Cook Inlet, are described in subsection 2.3 of this report (see figure 2-15). Medium draft and deep draft vessels now call at Homer in Kachemak Bay, Kenai on the Kenai River, and at a number of liquid bulk terminals near Nikiski on Cook Inlet north of the Kenai River. The medium draft vessels which offload and load at the new Homer cargo dock do not suffer chronic delays on approach or departure. Problems related to rough seas at the dock are minimal, since the dock faces Kachemak Bay and is protected by Homer Spit from waves of Cook Inlet. Deep draft vessels intermittently anchor in deep water near Homer for exchange of crews or other unscheduled services. Cook Inlet pilots are delivered from Homer, from the small boat harbor at Ninilchik, or from other small boat launch facilities along the Kenai Peninsula.

Liquid-bulk carriers calling on terminals in the Nikiski area do not chronically suffer tidal delays, since these privately owned facilities are maintained at depths adequate for the ships they serve. Problems related to rough seas or ice rarely hamper operations. The Kenai River is navigable by medium draft vessels only at high tide. The Port of Kenai typically is served by shallow draft barges and commercial fishing vessels. A Corps of Engineers study of navigation problems in the Kenai River was completed in April 1988. This report reviewed previous studies of navigation problems on the Kenai River and concluded that no economically feasible alternatives existed at that time. The most chronic problem in 1988 was found to be congestion of shallow draft commercial fishing vessels. This congestion continues to occur on roughly the same scale, but no major changes in physical or economic conditions point to a potential change of the previous report's conclusion.

The Pebble Beach prospect for mining of gold and other minerals north of Iliamna Lake on the Alaska Peninsula (USACE Alaska District 1988) could lead to export of bulk minerals from the west side of Cook Inlet. The Corps of Engineers is currently investigating a shallow draft channel into Williamsport on Iliamna Bay. This channel serves an existing road to Lake Iliamna at Pile Bay. The proposed shallow draft channel would provide access to barge and landing craft carriers of general cargo bound for Iliamna Lake communities. The dirt-and-gravel road from Williamsport to Pile Bay is used only in summer because it crosses steep terrain and is subject to winter avalanches. This seasonal constraint on use of the road and the shallowness of Iliamna Bay limit present prospects for deep draft improvements. Another site with equivalent difficulties for deep draft port development has been suggested on Iniskin Bay, north of Iliamna Bay on the west side of Cook Inlet. The Pebble Beach mine is not likely to be developed in the next 5 to 10 years or more; thus no current prospect for Federal participation in deep draft improvements appears to exist in the area.

Problems in other areas of lower Cook Inlet associated with shallow draft vessels are currently being addressed through the Corps of Engineers' small project continuing authority programs. No Federal interest in deep draft navigation improvements appears to exist in lower Cook Inlet at this time.

3.2 Deep Draft Navigation in Upper Cook Inlet

The southernmost deep draft facility in upper Cook Inlet is at Tyonek on the North Foreland. The dock face is not maintained to its original -34 ft MLLW, but present traffic consists primarily of medium draft and shallow draft barges. The pending development of the Beluga coal fields to the west (see figure 2-6) could bring about a need for deeper draft coal loading facilities at this site or, as proposed by various interests, at nearby Granite Point or Ladd Landing. Two major coal developers are exploring for coal in the hinterland and may each ultimately develop a coal loading facility near Tyonek. It appears unlikely that coal will be transported overland to ports farther up the inlet, though new road and rail lines have been discussed. Coal exports from the Beluga fields appear to be 5 to 10 years or more in the future. No Federal interest appears to exist at this time related to export of Beluga coal or other cargoes to or from the west side of upper Cook Inlet.

Across the inlet on the east side is the Port of Anchorage, Alaska's largest containerized and break-bulk cargo port. Anchorage and the areas it directly serves by road, rail, and air include more than 80 percent of Alaska's population (see figure 2-14). Anchorage is the commercial center of the State, and the municipal port facilities serve as the region's primary maritime link to the Pacific Rim. All deep draft vessels suffer tidal delays approaching and departing the Port of Anchorage. The maneuvering area at the dock is now authorized for Federal maintenance at -35 ft MLLW (see figure 2-17), which requires excavating an average of 225,000 cubic yards of silt each year. Fire Island Shoal and Knik Arm Shoal lie across shipping routes into the port (figure 3-1), and neither shoal is passable by many ships at low tide. Recent changes in the route across Fire Island Shoal, west of Fire Island, have greatly reduced this shoal's hindrance to ships approaching Anchorage. Preliminary results of a 1992 NOAA hydrographic survey indicate that Knik Arm Shoal causes more hindrance than before, due to encroachment by North Point Shoal to the north. A Federal interest in navigation improvements related to Fire Island Shoal and Knik Arm Shoal tidal delays exists and has been the subject of previous studies. These studies found no economically feasible alternatives, but recent changes in shipping and port-related costs warrant further investigation of the feasibility of excavated channel improvements. The port has recently expanded its liquid-bulk hauling facilities and enhanced its break-bulk and container handling equipment. Freight liner services calling on Anchorage have powered their vessels to be unusually fast (more than 20 knots) in transits from Tacoma to Anchorage. Totem Ocean Trailer Express (TOTE) is building a third roll-on, roll-off vessel for its growing Anchorage trade. The physical aspects of alternative channel improvements are discussed in more detail in section 4 and appendix B of this report. Tidal delays suffered

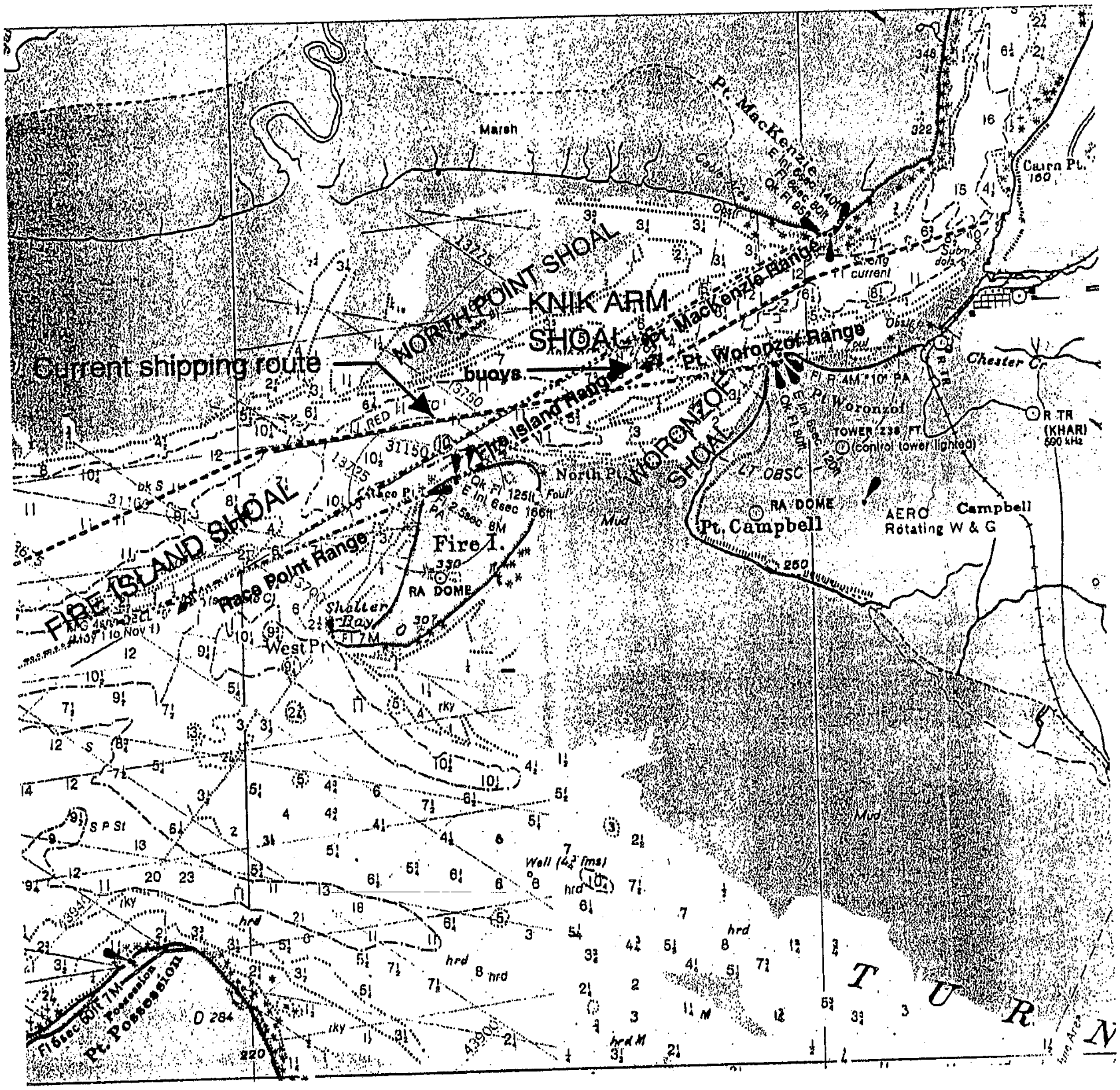

FIGURE 3-1.--Current shipping route in upper Cook Inlet, with aids to navigation.

by deep draft vessels were investigated by numerical simulations, as described in the next subsection and in appendix D.

The feasibility of a new port facility on Fire Island was investigated recently by the State of Alaska but was found to be too expensive for immediate State investment. A principal incentive for this development was to avoid the delays caused by Knik Arm Shoal, which lies between Fire Island and the Port of Anchorage. It now appears no port development will occur on Fire Island in the foreseeable future, and thus no associated Federal interest exists.

Coal deposits in the Matanuska River valley within the Matanuska-Susitna (Mat-Su) Borough may be developed for export in the next 5 to 10 years. The borough has been planning a port development since 1981 known as Port MacKenzie, to be located on the west side of Knik Arm north of Point MacKenzie. This facility, as currently planned, would initially include a tideland fill for near-term export of timber products from the borough. The second phase would include a coal trestle extending to natural depths of 60 ft or more at low tide. This facility is envisioned as requiring no routine maintenance dredging, either at the dock or in the adjacent maneuvering area. The Panamax-class coal carriers which would call at Port MacKenzie would benefit significantly from any channel improvements across Fire Island or Knik Arm Shoal, however.

3.3 Simulation of Ship Transits of Cook Inlet

3.3.1 Modeling Objectives. The pilots of ships traveling to or from Anchorage have for decades crossed Knik Arm and Fire Island Shoals on high water by slowing their ships in lower Cook Inlet on approach or waiting at the dock on departure. Delays therefore occur in two forms: (1) extra time spent approaching Anchorage slowly in order to meet high tide at the shoals, and (2) time spent at the dock ready for departure waiting for high tide at the shoals. Both are difficult to measure directly from port records or ship's logs. The application of average tide conditions ignores the variability of the delays and assumes perfect planning of the approach. A numerical model was designed to simulate pilot decisions and realistic application of their decisions for the transits of individual ships from their port of origin to Anchorage, their time at the dock, and their departure across the shoals. Features of the model were formulated to provide a discrete measure of delays incurred for each ship transit simulated. The following paragraphs summarize the methodology and results of the simulations. The application of these results in evaluating project feasibility is discussed in appendix C of this report. A detailed technical description of the simulations is presented in appendix D.

3.3.2 Methodology. The computer program relies on data derived from 1991 records of the Port of Anchorage and from information on ship departures, cargo loads, and vessel characteristics provided by shippers serving the port. The program simulates a pilot's decision-making process by forming a plan when the simulated voyage reaches lower Cook Inlet. The plan involves slowing the vessel from its open-sea cruise speed for a duration designed to bring the ship to Knik Arm Shoal at a particular high tide. Hourly tide heights and currents for 1991 were predicted at 15 locations along Cook Inlet. The pilot's plan, once formulated, was executed by the program in small increments of time and motion from lower Cook Inlet all the way to the port. The effect of opposing or following tidal currents, whose speed often exceeds 3 knots, was included in this part of the simulation. The simulated time of arrival at the dock is compared to the time the ship would have arrived at full cruising speed and reported as a delay.

Upon arrival at the port, the time to berth at the dock is simulated. Time waiting for the next longshoremen's work shift to begin is also simulated. Once the scheduled work shift has begun, the unloading and reloading of the vessel's cargo is simulated. Once cargo transfer operations are complete, the vessel is considered ready to depart. A pilot plan for departure is formulated at this time, in a manner equivalent to that on approach. The plan is executed when the chosen tide conditions are reached, and the ship's departure and travel down the inlet and across the shoals are simulated. The time waiting for a work shift to begin, the cargo transfer time, and the time waiting for the tide to depart are all reported for each ship in the program output.

3.3.3 Verification. The records of actual 1991 arrivals at and departures from the Port of Anchorage were compared to the simulated arrivals and departures. The practical criteria for judging the accuracy were for simulated arrivals and departures to occur on the same high tides as recorded arrivals and departures. High tides occur approximately every 12-1/2 hours in upper Cook Inlet, so a difference of 7 hours or more implies that different high tides were involved. Simulated arrivals for 199 containership arrivals in 1991 averaged 0.5 hours difference from recorded arrival times. Simulated departures for these vessels averaged 5.7 hours difference from recorded departure times. The larger departure errors are attributed to inaccuracies in simulating the variability of work shifts and cargo transfer rates. Both differences are acceptable at this reconnaissance level of study in terms of the evaluation criteria. The model is judged to provide an adequate measure of actual delays suffered by vessels related to crossing the shoals.

3.3.4 Results. Fire Island Shoal presently has a natural controlling depth of 48 feet at low tide. Knik Arm Shoal has a controlling depth of 25 feet at low tide. The two shoals are about 20 minutes apart, in terms of the travel time of a ship approaching Anchorage. The constraint of Knik Arm Shoal is much more severe, so this shoal is directly responsible for all delays. Any approach which will pass safely over Knik Arm Shoal is guaranteed also to pass safely over Fire Island Shoal with an additional 20 feet keel clearance. The simulations of 1991 traffic showed that 101 Sea-Land Freight Service, Inc. (Sea-Land) ships each incurred an average 3.8 hours tidal delay. Results for 98 Totem Ocean Trailer Express (TOTE) ships show an average 5.9 hours tidal delay per ship. TOTE vessels require a flood tide for berthing so that pilots can maneuver the ships into the current for a port-side landing. Ramps for roll-on/roll-off operations are on the port side of the ships. Tankers and other deep draft vessels were predicted to average 3.1 hours tidal delay per ship, but these delays were not addressed further in this reconnaissance analysis.

A variety of alternative simulations were made for these same ships with the natural depth of Knik Arm Shoal deepened to simulate the operational effect of a dredged channel. The differences between the delays simulated for these alternative inlet conditions and those simulated for natural conditions reflect the delay savings achieved by the dredging. A channel dredged to 35 feet at low tide across Knik Arm Shoal reduced delays for the three vessel groups above to 1.3, 2.8, and 0.4 hours, respectively. This amounts to an average time savings of 2.5, 3.1, and 3.1 hours, respectively. Incremental delays for containerships are presented in table 3-1. Shippers have reviewed these results and agree that they are realistic. These average time savings correspond to tangible cost savings, i.e. project benefits, which are derived later in this report.

TABLE 3-1.--*Estimated average delay times in hours per transit*

		Without project		With project		Time savings with project	
Carrier	No. ships	Arrival delay	Departure delay	Arrival delay	Departure delay	Arrival	Departure
Sea-Land	101	3.2	0.6	1.2	0.1	2.0	0.5
TOTE	98	4.8	1.1	2.8	0.0	2.0	1.1

4. PLAN FORMULATION

4.1 Findings of Previous Studies

4.1.1 Corps of Engineers Studies. The following reports have been published by the U.S. Army Corps of Engineers with regard to deep draft navigation improvements in Cook Inlet.

- **House Document No. 34, 85th Congress. 1956 (Oct). "Cook Inlet and Tributaries, Alaska: Letter from the Secretary of the Army," U.S. Government Printing Office, Washington, DC, 142 pp.** This report to Congress summarized the review of reports by the Alaska District of the Corps, which recommended a deep draft harbor at Anchorage and small boat harbors at Homer, Seldovia, and Ninilchik. Prior to this document, the only authorized navigation project on Cook Inlet was a boat harbor at Seldovia (originally authorized in 1945). The dock at Anchorage at that time had been constructed by the Alaska Railroad (U.S. Department of the Interior) in 1919 and rehabilitated for military uses by the U.S. Army.

- **U.S. Army Corps of Engineers, Alaska District. "Review of Report on Cook Inlet and Tributaries, Cook Inlet Shoals, Cook Inlet, Alaska - Public Meeting, Anchorage, Alaska, 30 November 1970," Anchorage, 58 pp.** This transcript of verbal and written statements presented at a public meeting discusses the constraints to shipping caused by Fire Island and Knik Arm Shoals. Support for further studies was prevalent, but representatives from Seward pointed out that additional Federal dredging might not be as efficient as diverting cargo from Anchorage to Seward. The Corps of Engineers presented some limited survey information, including results of seismic sub-bottom surveys at Knik Arm Shoal. The shoal was revealed to be formed of cobbles and boulders, covered with varying thicknesses of gravel and sand. The rocks forming the base of the shoal were assumed to be a glacial deposit.

• **U.S. Army Corps of Engineers, Alaska District. 1978 (Jun). "Cook Inlet Shoal, Alaska, Feasibility Report, Channel Improvement for Navigation," Anchorage, 42 pp.** This study specifically addressed the tidal delays to shipping caused by shoals along the approaches to the Port of Anchorage. A proposal for a channel improvement on Knik Arm Shoal, referred to in the study as "Cook Inlet Shoals," was not found to be economically feasible. The average delay for 32-ft-draft vessels was estimated to be 2.9 hours, assuming a controlling shoal elevation of -15 ft MLLW. Estimated annual shipping cost savings of $513,000 associated with reduction of these delays did not offset the estimated $3,550,000 first cost and $1,000,000 annual maintenance cost of a channel 2,000 ft wide at -35 ft MLLW, centered on the Fire Island Range.

• **U.S. Army Corps of Engineers, Alaska District. 1981 (Jan). "Southcentral Region of Alaska Deep Draft Navigation Study," Anchorage, approx. 200 pp.** This study addressed regional waterborne commerce needs by forecasting cargo trends and assessing the cargo handling capacity of regional ports. No channel improvements in Cook Inlet were recommended. The study suggested that the Port of Anchorage may want to deepen its berths and approaches from -35 ft to -38 ft MLLW to accommodate the larger container ships which worldwide trends indicated might serve the region in the foreseeable future. The study noted that excess capacity at Seward and Valdez could serve to alleviate future congestion at the Port of Anchorage. The tidal constraints of Fire Island Shoal and Knik Arm Shoal were not addressed. The study in general emphasized improvements to cargo handling facilities in response to future cargo throughput trends. A Federal interest in deep draft improvements at Kodiak was identified, which led to further studies at Kodiak. These studies did not result in any new deep draft cargo facilities at Kodiak, due primarily to the high cost of construction. Construction of a Federal breakwater to protect a harbor for commercial fishing vessels is scheduled to begin in 1993 on Near Island at Kodiak.

• **U.S. Army Corps of Engineers, Alaska District. 1986 (Sep). "Interim Technical Report, Southcentral Alaska Deep Draft Navigation Study, Fire Island Shoal at Anchorage," Anchorage, 25 pp.** This study responded to increasing concerns of maritime interests about shoaling trends along the shipping route past Fire Island. The charted shipping route passed between Fire Island and the crest of Fire Island Shoal to the west. The study demonstrated that the crest of Fire Island Shoal, composed of uniform sand, had migrated southeastward since 1941 until the -30-ft-MLLW contour encroached upon the Point MacKenzie Range marking the center of the shipping route. The study concluded that conditions at that time did not warrant any channel improvements, but that periodic surveys should be performed to monitor further shoal migration. Since this study, most ships have abandoned the Point MacKenzie Range in favor of passage to the north of the crest of Fire Island Shoal, where the 1992 controlling elevation is -48 ft MLLW over a wide area.

• **U.S. Army Corps of Engineers, Alaska District. March 1988. "Anchorage Deep Draft Interim Technical Report," Anchorage, 77 pp.** The report considers options to reduce the cost of waterborne commerce into and out of Anchorage. The focus was on the annual Federal maintenance dredging at the existing port and the shoals which caused tidal restrictions to ships approaching and departing Anchorage. The study evaluated diversion of cargo from Anchorage through other regional ports, including Whittier, Seward, and Valdez. The study found that Anchorage was preferred by shippers because Anchorage itself is Alaska's largest market for consumer goods and other supplies. Anchorage was found to offer diverse and competitive transshipment services by road, rail, and air to all parts of the State, firmly establishing the Port of Anchorage as the State's largest general cargo port and import transshipment center.

Changing the dredging geometry at the port was suggested as a means to reduce annual dredging quantities. Modifications to the dredging plan have since been accomplished and seem to have reduced the quantities. The study found no need to deepen the port adjacent to the dock. Potential future congestion at the Port of Anchorage was addressed by proposals for expansion of the existing municipal port, a new port on Fire Island, and a new port on Point MacKenzie. Indications were, however, that the existing Anchorage port facilities could handle the modest cargo increases that the study projected for several decades. Channel improvements over Fire Island and Knik Arm Shoals were considered, but neither was found economically feasible. A 1,600-ft-wide channel across Knik Arm Shoal at -35 ft MLLW was estimated to cost $5,530,000 for initial excavation and $1,580,000 for annual maintenance dredging.

• **U.S. Army Corps of Engineers, Alaska District. 1989 (Aug). "Preliminary Reconnaissance Report, Fire Island, Anchorage, Alaska," Anchorage, 38 pp.** This study was conducted under the small project continuing authority of Section 107 of the River and Harbor Act of 1960, as amended. The study evaluated the Federal interest and apparent feasibility of a new deep draft port on Fire Island to serve the Anchorage area. The study was requested by the Municipality of Anchorage following a proposal for a Fire Island port development by the private group Commonwealth North. The extensive annual maintenance at the existing Port of Anchorage and the tidal constraint of Knik Arm Shoal (between Fire Island and the existing port) were cited as incentives for a Fire Island port. The causeway required for access to Fire Island was envisioned to serve as the protective breakwater for a small boat harbor. These developments were all found to be beyond the scope of Section 107 authority, and studies under General Investigations (congressionally approved) authority were recommended. This recommendation in part lead to the initiation of the present study.

4.1.2 Studies by Others. Many published studies and unpublished data collection efforts by other Federal, State, and local agencies were reviewed for this study. The Annotated Bibliography, published as a separate volume, includes a complete list of the references consulted. The most important are listed in the References section at the end of this report. Three published studies of special relevance to the conclusions of this report are described below.

• **U.S. Coast Guard. 1991 (Sep). "Waterway Analysis for Cook Inlet West/North," Seventeenth Coast Guard District, Juneau, Alaska, approx. 150 pp.** This report summarizes a study of current navigation practices in upper Cook Inlet and the adequacy of the current system of aids to navigation. The Coast Guard investigators found that deep draft vessels approaching Anchorage no longer follow the Race Point Range to the south of the crest of Fire Island Shoal. Pilots instead now guide their vessels to the north of the crest, avoiding shallower water and associated tidal delays. The report concludes that the navigation aid system along the approaches to Anchorage should be modified to accommodate this practice. Figure 3-1 in the previous section shows the present system of aids to navigation, as reviewed by the Coast Guard. A summary of the actions proposed by the Coast Guard in this study follows.

a. NEAR-TERM ACTIONS (AS OPERATIONS AND EQUIPMENT PERMIT)

(1) Increase the nominal range of East Foreland Light from 7 nautical miles (nmi) to 9 nmi.
(2) Increase the nominal range of Moose Point Light from 5 nmi to 9 nmi.
(3) Increase the nominal range of Fire Island Light 6 from 5 nmi to 7 nmi.
(4) Increase the nominal range of Point Possession Light from 7 nmi to 9 nmi.
(5) Add a radar beacon (RACON) to Moose Point Light.
(6) Add a RACON to Fire Island Light 6.
(7) Research and submit requests to chart the various radio/microwave towers along Cook Inlet, particularly from Anchor Point to Kenai and around the city of Anchorage.
(8) Initiate numerous minor chart and publication corrections.

b. MID-TERM ACTIONS (WITHIN 2 TO 3 YEARS)

(1) Increase the nominal range of East Foreland Light from 9 nmi to 15 nmi using shore power.
(2) Establish a 15-nmi light on North Foreland using shore power.
(3) Establish a 12-nmi light with a RACON in the drainage of the Little Susitna River near Magot Point in approximate position 61°16' N., 150°30' W.

c. LONG-TERM ACTIONS (WITHIN 5 YEARS)

(1) NOAA should conduct an extensive hydrographic survey of Upper Cook Inlet, particularly around Fire Island Shoal, to determine the best passage affording safest water around this shoal *(accomplished in 1992).*
(2) Based on NOAA findings, the Coast Guard could possibly reconstruct or move Terrestrial Ranges as appropriate around Fire Island to make use of the best channel.
(3) Relocate Cook Inlet Lighted Buoy 3 to indicate the preferred channel.

• **CH_2M-Hill. 1991 (Dec) (draft). "Fire Island Deep Water Port Facility - Constructability Analysis, Market Potential, and Economic Feasibility Analysis," Alaska Industrial Development and Export Authority (AIDEA), Anchorage, approx. 200 pp.** This report was commissioned by AIDEA, a State-incorporated agency, to determine the advisability of State purchase of private lands on Fire Island for future construction of a deep draft port facility. The port was to be designed for export of coal and other bulk materials. The primary site for the port was Race Point, a prominence on northwest Fire Island. Race Point is near natural depths of 60 feet and greater. The constraint of Knik Arm Shoal would not affect a Fire Island port, and this circumstance was cited as a major incentive for the proposed Race Point development. An expensive causeway from Point Campbell to Fire Island would be required. Point Campbell is now developed as popular park lands and suburban housing. The causeway expense, its environmental impacts, and its potential impact on traffic and noise on Point Campbell would be highly controversial. The ultimate conclusion of the study and the peer review process which followed was that a port development on Fire Island was not economically feasible. Since a Federal interest may have existed in both channel improvements and in breakwater construction at Fire Island, this conclusion was critical to the direction of the present Corps study.

• **Peratrovich, Nottingham, and Drage, Inc. 1993 (Jan). "Southcentral Ports Development Project," Alaska Department of Commerce and Economic Development (ADCED), Anchorage, approx. 200 pp.** This study was initiated by the State of Alaska during the course of the present Corps effort. The ADCED managers accepted suggestions from the Corps for the contract scope of work. The study has, as a result, been a significant source of information on the current status of ports in the region and projections of cargo throughput into and out of Cook Inlet ports and competing ports in Southcentral Alaska.

The study recommends specific port developments, particularly for export of timber products and coal. Three options for coal export are discussed: (1) through the existing coal export terminal at Seward, (2) through a proposed new bulk terminal at Port MacKenzie (across Knik Arm from Anchorage), and (3) through a new bulk terminal north of the existing Port of Anchorage. The coal-related findings of the study are controversial. Though the draft report appears to favor a new port at Port MacKenzie for long-term efficiency, reviewers presented many pages of comments and facts in support of the other options. Timber products export was less controversial, since this resource is distributed so that many ports may efficiently provide export capacity with limited capital improvements. The report projects the Port of Anchorage to continue as the State's leading containerized cargo port for the next 40 years or more. The prospect of an excavated channel across Knik Arm Shoal is described as a worthy measure for improving transportation efficiency through the Port of Anchorage to Southcentral Alaska.

4.2 1992 Field Data Collection and Analysis

Scientific literature and previous studies of public works prospects revealed a great deal of information on physical and economic constraints to channel excavation in upper Cook Inlet. The 1992 hydrographic survey independently scheduled by NOAA provided an extraordinary opportunity to supplement knowledge of physical conditions in the upper inlet. The NOAA ship *Rainier* supported measurements made by the Corps during the hydrographic survey in July 1992. The following paragraphs describe the measurements made and subsequent data analyses. Appendix B provides a more detailed description, and "Upper Cook Inlet, Alaska, Field Data Collection, July 1992 - Data Report" (Smith, in preparation, February 1993) provides a complete technical presentation of the interpreted field data.

4.2.1 Summary of Measurements. The limits for the *Rainier*'s hydrographic survey are indicated in figure 4-1. The locations of Corps measurements are indicated in figure 4-2. The measurements included current profiles (surface to bottom) with an acoustic Doppler current profiler (ADCP), water temperature and conductivity profiles,

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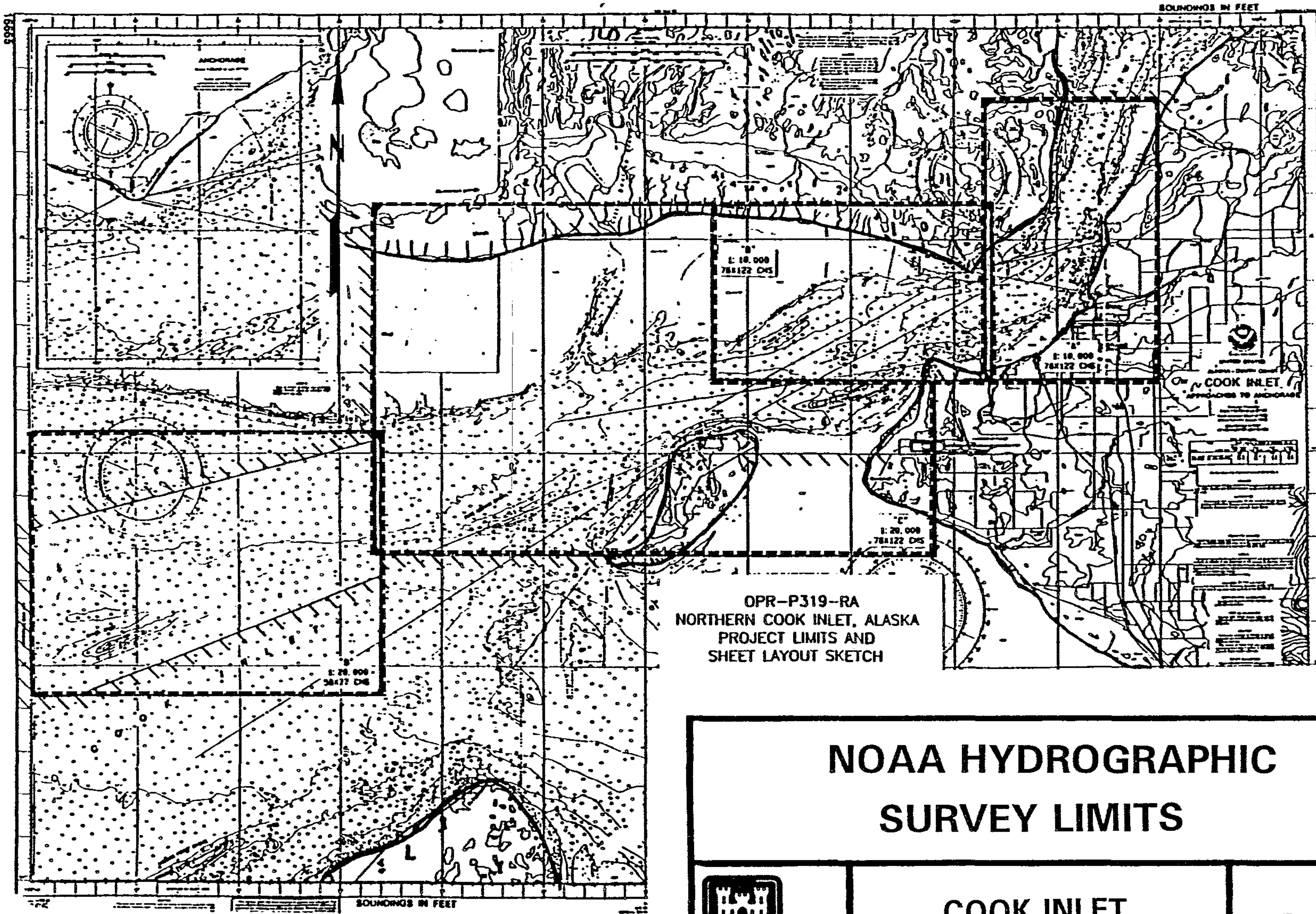

N.T.S.

NOAA HYDROGRAPHIC SURVEY LIMITS

US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

4-1

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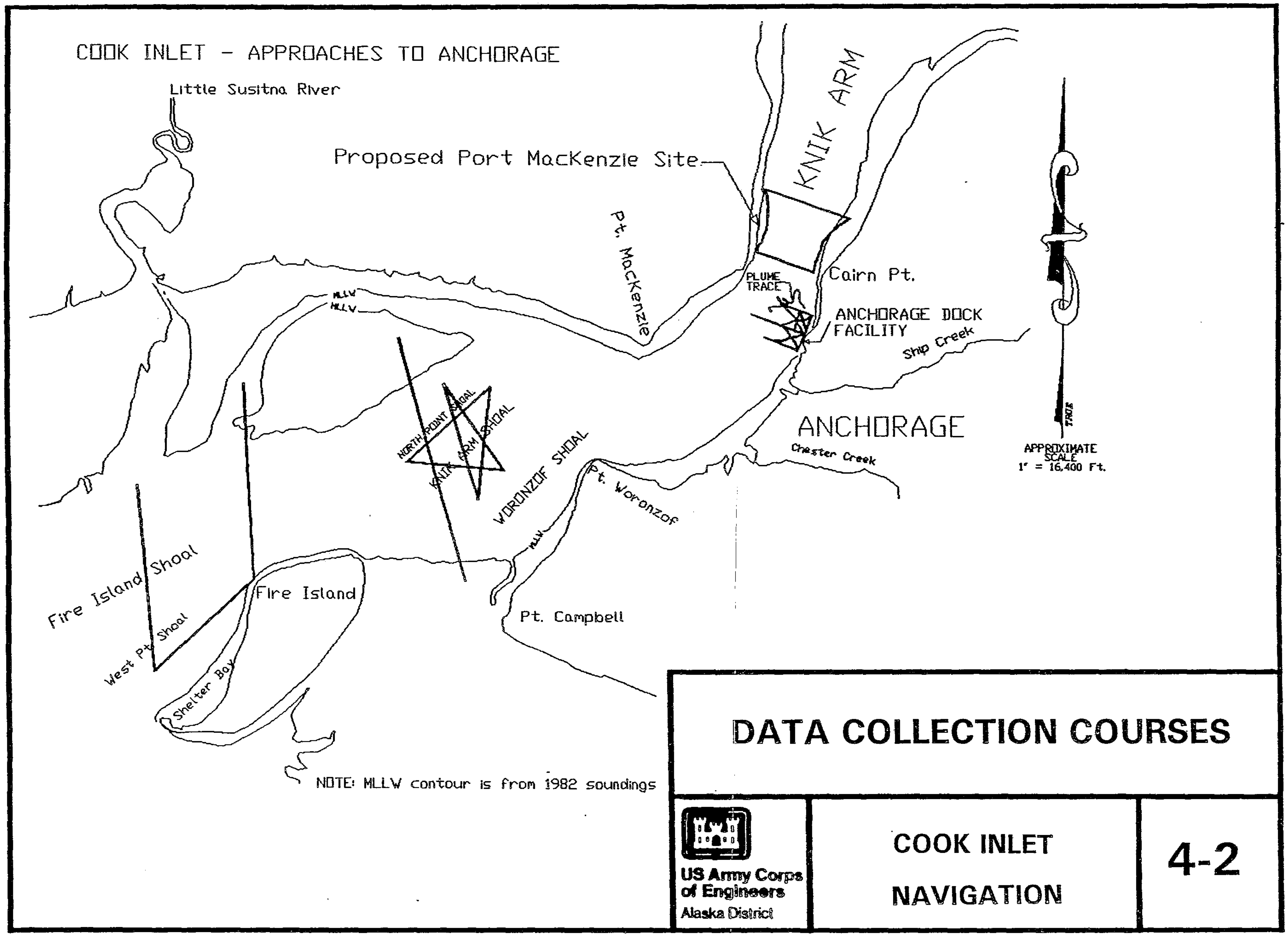
COOK INLET - APPROACHES TO ANCHORAGE
Little Susitna River
Proposed Port MacKenzie Site
KNIK ARM
Pt. MacKenzie
Cairn Pt.
PLUME TRACE
ANCHORAGE DOCK FACILITY
Ship Creek
ANCHORAGE
Chester Creek
APPROXIMATE SCALE
1" = 16,400 Ft.
TRUE
MLLV
MLLV
NORTH POINT SHOAL
KNIK ARM SHOAL
WORONZOF SHOAL
Pt. Woronzof
MLLV
Fire Island Shoal
Fire Island
West Pt. Shoal
Shelter Bay
Pt. Campbell
NOTE: MLLW contour is from 1982 soundings
DATA COLLECTION COURSES
US Army Corps of Engineers
Alaska District
COOK INLET
NAVIGATION
4-2

profiles of optical backscatter (*i.e.*, turbidity), water samples at various depths and locations, samples of bottom materials, and acoustic echo amplitude (suspended sediment concentration) profiles. NOAA provided more than 120 bottom material samples from across the survey area which had been collected routinely for the sake of chart annotations.

4.2.2 Summary of Data Analyses. The NOAA ship *Rainier* provided a preliminary version of the hydrographic survey data, as corrected and edited aboard the ship for review by NOAA's Pacific Marine Center (PMC) at Seattle. This preliminary data included soundings (water depth measurements) corrected by predicted tide heights to estimate the elevation of the bottom with respect to mean lower low water (MLLW, *i.e.*, low tide). These bottom elevations were used for comparison with the published chart, which was based on soundings made in 1982, and with hydrographic change analyses made in previous studies. These elevations were also applied to compute excavation quantities for various proposed channel configurations.

Figure 4-3 presents a comparison of 1992 *Rainier* data with the published chart. Different contouring procedures were applied, which complicates interpretation of details, but major trends are reliably revealed. North Point Shoal, north of Knik Arm Shoal, has made a massive southward migration, almost reaching Knik Arm Shoal to the northwest at the -30-ft contour. North Point Shoal also appears to have eroded somewhat to the northeast of Knik Arm Shoal. Woronzof Shoal, south of Knik Arm Shoal, has expanded northward toward Knik Arm Shoal, though it remains well clear of the presently marked shipping route along the Fire Island Range. The -60-ft contours were difficult to interpret from the *Rainier* data, probably due to inaccuracies in the tidal corrections applied by the ship. These inaccuracies will be corrected with an array of precise water level measurements made concurrent with the soundings, before NOAA publishes nautical chart changes in 18 months to 2 years (personal communication, Lt. Dave Cole, NOAA, PMC). In spite of this difficulty, there is some indication of scouring along the Fire Island Range, which would be consistent with a hydraulic constriction on both sides

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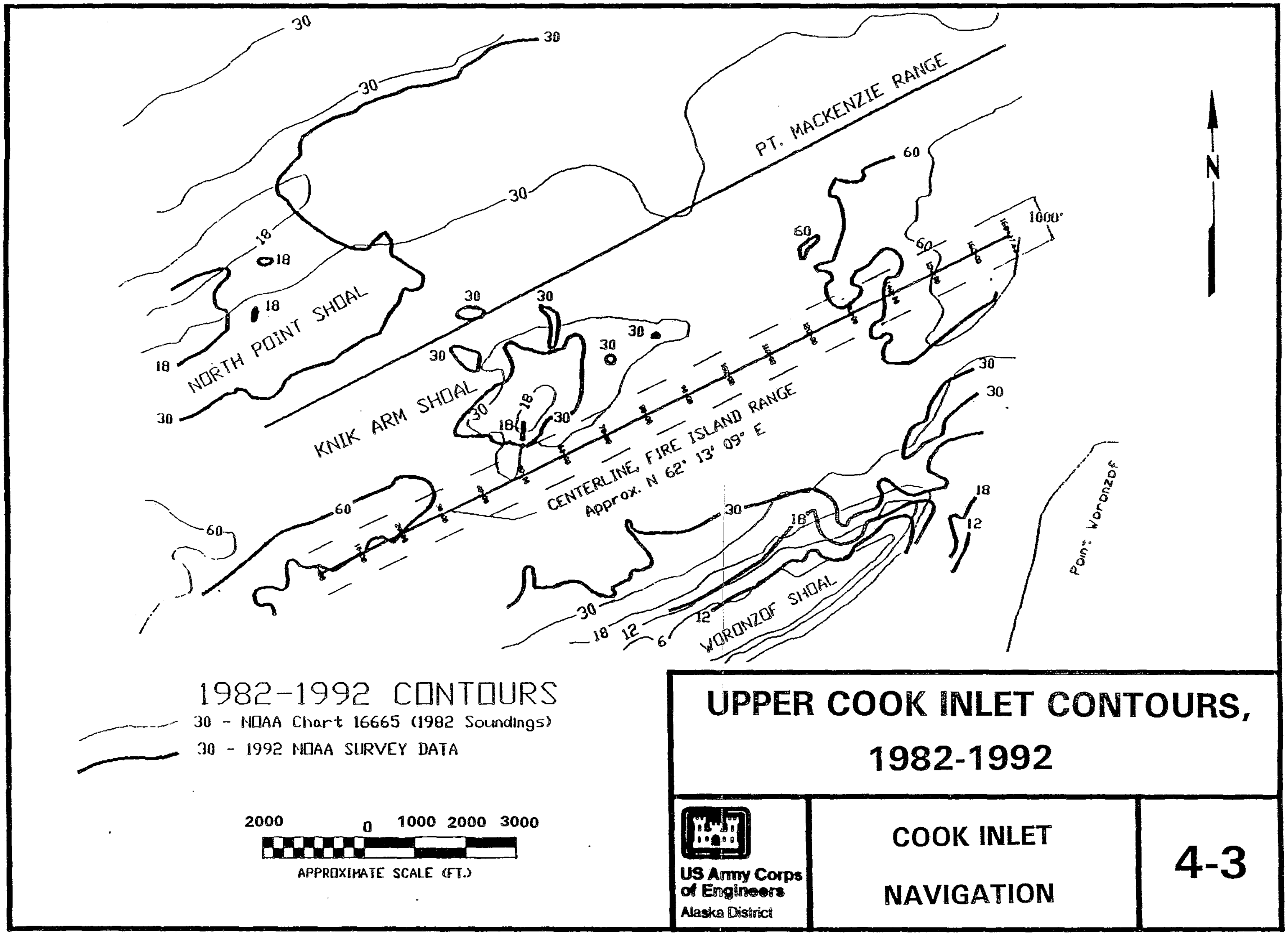


PT. MACKENZIE RANGE
NORTH POINT SHOAL
KNIK ARM SHOAL
CENTERLINE, FIRE ISLAND RANGE
Approx. N 62° 13' 09" E
WORONZOF SHOAL
Point Woronzof
N
1000'
30
60
18
12
6
1982-1992 CONTOURS
30 - NOAA Chart 16665 (1982 Soundings)
30 - 1992 NOAA SURVEY DATA
2000 0 1000 2000 3000
APPROXIMATE SCALE (FT.)
UPPER COOK INLET CONTOURS, 1982-1992
US Army Corps of Engineers
Alaska District
COOK INLET NAVIGATION
4-3

of the channel. Depths along the south flank of Knik Arm Shoal appear to have changed little since 1982, indicating bottom features which resist scouring. Least depths near the Fire Island Range appear as pinnacles at -25 to -27 feet MLLW.

The *Rainier* collected bottom material samples regularly spaced over the entire survey area shown in figure 4-2. The Corps collected additional bottom material samples in the immediate vicinity of Knik Arm Shoal. The small but efficient grab (clamshell-type) sampler notably could collect no sediment in seven tries at the highest point of Knik Arm Shoal. This usually indicates a very hard bottom. All samples collected between Point Woronzof and Fire Island were classified by appearance and tested for grain size distribution. The median grain size for most samples was on the order of 0.4 mm, or in the range of medium to fine sand. This sand could originate from the rivers flowing into the upper inlet and from eroding bluffs along the inlet shore. A few coarser samples were collected near the crest of Knik Arm Shoal and near the tip of Point Woronzof. It seems likely, based on these data and previous geotechnical measurements, that both Point Woronzof and Knik Arm Shoal are based on consolidated glacial deposits of boulders, cobbles, and gravel. The predominant sand appears to have washed over most of this larger material, except at the highest submerged points where coarser material from the glacial deposit is exposed.

Acoustic current measurements were made by a continuously recording broad-band 614-kilohertz ADCP system. This instrument was provided by the U.S. Army Engineer Waterways Experiment Station at Vicksburg, Mississippi, through a contract with RD Instruments of San Diego, California. The basic operating principles of this instrument are explained in appendix B and in Smith (in preparation, February 1993). Current data was continuously provided for every 3 ft (1 m) of depth and approximately every 32 ft (10 m) along tracks as indicated in figure 4-2. Courses across the waterway were repeated on the flood and the ebb flows surrounding a single slack tide (either high or low tide). A star-shaped continuous pattern was followed on both the flood and the ebb one day, as a means of resolving net circulation or cross-channel flow trends.

Approximately 160 megabytes of digital ADCP data were recorded, only a small select portion of which has been reviewed in detail. Representative current data along transects at Knik Arm Shoal indicate that current speeds in the upper water column can exceed 4 knots, but the average (surface to bottom) current speed during maximum flood or ebb flows is typically 3 to 3-1/3 knots.

Intermittent stops were made to lower a conductivity-temperature-depth (CTD) sensor array. This device measured these parameters continuously while in the water. Salinity, the amount of dissolved material in the water, and density are readily computed from concurrent temperature and conductivity measurements. Salinity and density are then associated with depth, as measured by a pressure sensor. Temperatures and salinities were generally uniform with depth. Typical temperatures were around 14.5 °C. Salinities varied from 6 to 11 parts per thousand, tending to be saltier west of Fire Island. Salinities of the Gulf of Alaska are on the order of 32 parts per thousand.

The CTD used in upper Cook Inlet was also equipped to measure optical backscatter (OBS) as an indication of suspended sediment concentration. The OBS data was calibrated with water samples of known suspended sediment concentration. Water samplers of 6 liters volume were lowered on the cable which held the CTD sensors. The number of samples and the depths at which they were captured varied according to total water depth and vertical variability revealed by acoustic data. The water from the samples was subsequently filtered, the filtrate weighed, and the grain size distribution determined. The weight (mass) of the filtrate provided a direct measure of the suspended sediment concentration at the place and time of the sample collection. Concentrations varied widely, from tens of milligrams sediment per liter of water (mg/l) to a maximum of nearly 4,000 mg/l. These concentration data were applied to calibrate the OBS data and two acoustic echo amplitude measurements. Concentrations derived from OBS data show two alternate trends: either uniform concentration with depth or a steady increase of concentration with depth.

The grain size distributions of the water sample filtrates indicate that suspended materials are predominantly silt, with some occasional fine sand mixed in (especially closer to the bottom). The median grain size of suspended material was typically from 0.004 mm to 0.016 mm. Silt was not found except as a small fraction of bottom samples in the study area, indicating that currents are too energetic to allow any settlement of this fine material without almost immediate resuspension.

Two means of acoustic measurement of suspended sediment concentration were applied. One acoustic beam from the ADCP unit was dedicated to measurement of the amplitude of acoustic pulses in the manner of a fathometer. The signal was calibrated to provide a measure of the density of reflectors in the water, *i.e.*, the suspended sediment concentration. The second acoustic concentration system was provided by NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML). The AOML system used two acoustic beams at different frequencies to accomplish the same objective with higher resolution. The focus on suspended sediment was planned with a view toward the heavy settlement of silt that occurs a few miles away at the Corps-maintained Port of Anchorage. If this mode of sedimentation had been encountered at Knik Arm Shoal, measurement of suspended transport of silt would have been of paramount importance in maintenance dredging estimates. The combined field measurements reveal that bed-load transport of sand is the dominant mode of sedimentation and erosion in the vicinity of Knik Arm Shoal. Acoustic measurements revealed interesting vertical and lateral variations in concentration of suspended silt, with a more consistent trend toward concentrations increasing with depth than revealed by OBS data. The schedule and budget of this study limited the scrutiny of the acoustic data to only a few selected excerpts from the mass of information accumulated in the field, however.

4.3 Measures Involving No Excavation

4.3.1 Improved Aids to Navigation. The present system of visual ranges is used by pilots to locate their ships with respect to hazardous submerged shoals and points of land in all weather conditions. Knik Arm Shoal is marked by a pair of lighted buoys which are removed in the winter. Experience has shown that the stoutest of buoy moorings has little chance of survival in midwinter ice conditions. The 1991 "Waterway Analysis" by the U.S. Coast Guard found that the present system could be improved and recommended a series of enhancements, as discussed in subsection 4.1.2. The Coast Guard's aids-to-navigation experts participated in the coordination meetings that were a part of this study. A number of further improvements proposed in these meetings are under consideration by the Coast Guard. The most significant of these involves the Global Positioning System of satellite navigation (GPS), now commercially available for use through a variety of hardware and software products.

The basis of GPS positioning is triangulation by electronic distance measurements to any four of 24 satellites in relatively high orbits. Normal accuracy is within 100 feet. Much greater accuracy is possible through an adaptation of the GPS technology known as differential GPS (DGPS). DGPS uses a stationary reference receiver on a known location to transmit corrections for satellite-related errors to a second receiver. Radio telemetry is the usual means for transmitting the corrections between receivers, but commercially available arrangements vary and have not yet become standardized. Positioning accuracy with DGPS is within a few feet for a receiver in motion, such as a ship at sea (Hurn 1989). The Coast Guard has converted some of its outdated radio locator beacons to serve as DGPS shore stations, broadcasting corrections.

This highly accurate knowledge of ship's position is most useful to a pilot if he knows the position of nearby hazards to navigation with the same accuracy. Paper charts and manual position plotting do not provide this accuracy, but commercially available electronic chart display (ECDIS) systems make full use of DGPS and other available navigation aids (for example, RACON signals). A computer and sophisticated graphics display monitor provide the pilot with a chart showing with equal accuracy the ship's position and that of all nearby points of interest (*Marine Log* October 1992). The combination of DGPS and ECDIS technology in upper Cook Inlet would significantly improve the safety of the constricted passage into the Port of Anchorage. The Coast Guard is already considering this possibility (personal communication, Comdr. George Capacci, U.S. Coast Guard, 17th District, Juneau, December 1992).

4.3.2 Increased Frequency of Surveys. There are occasions when pilots underestimate risks by applying obsolete chart data and occasions when valuable time is lost by overestimating risks. NOAA has responsibility for hydrographic surveys of navigable waters in upper Cook Inlet and in the past has usually repeated surveys every 10 years. Recent public attention to the shoals of upper Cook Inlet has led NOAA to reevaluate this policy and consider repeating the surveys every 5 years (personal communication, Lt. Dave Cole, NOAA PMC, Seattle, December 1992). NOAA's normal time to plan and perform a survey and publish a new chart is about 3 years, but, as a practical matter, neither the agency's budget nor its priorities allow such frequent updates. More frequent surveys would require the efforts of some other agency. An authorized Federal channel would provide the Corps of Engineers with authority to accomplish annual or even more frequent surveys in the immediate vicinity of the channel. This is an important service provided at many Corps projects around the U.S. coast where the sea bottom is constantly shifting (*e.g.*, the Intercoastal Waterway). Local maritime interests could also accomplish the work. More accurate charts of the shoals along the approaches to the Port of Anchorage would improve the safety and efficiency of ship transits.

4.3.3 Modifications to Shipping Practices. Barges serving the Port of Anchorage suffer much less delay in crossing the shoals than the deeper-draft vessels, and often cross without any delay. Tug and barge operations can serve most of Alaska's many medium and shallow draft ports, or lighter ashore where there is no port at all. This mode of maritime transportation has been a mainstay for Alaska development for many decades. The large annual throughput at Anchorage is more efficiently accomplished by faster, larger-capacity vessels, however. The containerships of Sea-Land and TOTE have above average speed and power for vessels of their class, provided by the ship owners after many years' experience in the Alaskan trade. A shift to shallower-draft vessels involves reduced capacity, reduced speed at sea, and a significant reduction in efficiency. No major shift in shipping practices into upper Cook Inlet appears practical as an alternative to the present tidal delays.

4.3.4 Diversion of Cargo to Other Ports. Anchorage and Southcentral Alaska can be served by road and rail transshipment from ports not affected by the shoals of upper Cook Inlet. The interior of Alaska can be served by highway transshipment through the Port of Valdez. The Port of Whittier already receives cargo by barge, destined for Anchorage and interior Alaska via the Alaska Railroad. Whittier has deep water near shore and is ice-free all year, but has little available upland staging area, severe winter snowfall, and no road access. A plan to provide some road use of the railroad route to Whittier is under consideration by the Alaska Department of Transportation and Public Facilities (ADOT&PF). This potential new access appears to be aimed primarily at recreational visitors rather than heavy commercial traffic. The railroad will remain the most practical transportation to Whittier for heavy or large-quantity shipments. The quantities of containerized cargo coming into Anchorage are more efficiently offloaded by the high capacity equipment at the Port of Anchorage, where ample stacking area is available adjacent to the dock and multiple transshipment modes are readily available.

The Port of Valdez has underutilized capacity for containerized cargo. Containers and break-bulk cargo can be trucked from Valdez to Fairbanks and interior Alaska. The Richardson Highway from Valdez to Fairbanks has severe snowfall and avalanche hazards in the Thompson Pass area near Valdez. The Port of Anchorage has dominated containerized cargo transshipment to Fairbanks for more than a decade since Valdez has had a container terminal, in part because Anchorage has both rail and road access without the severe winter snowfall or avalanche hazards of Valdez. Diversion of Fairbanks cargo from Anchorage to Valdez appears unlikely.

The Port of Seward can receive break-bulk, containerized, and dry-bulk (coal) cargo for transshipment to Anchorage or the interior by either the Seward Highway or the Alaska Railroad. Resurrection Bay at Seward has deep water near shore and is ice-free all winter. Both the highway and the railroad have steep grades and significant winter snowfall. Some of the Seward Highway grades and avalanche risks have been reduced in recent years by realignment of the road and avalanche prevention measures. Summer recreational traffic is intense along the Seward Highway, and the ADOT&PF continues to plan road improvements. The mountain range between Seward and Anchorage will always be a deterrent to overland transportation of heavy and large-volume cargo. The prospect of diverting some containerized cargo from the Port of Anchorage to Seward for transshipment to Anchorage has been discussed among shippers and Port of Seward officials, but no such diversion has taken place. No regularly scheduled containership service is now available at Seward. The Southcentral Port Development Project (Peratrovich, Nottingham, and Drage December 1992) concluded that the Port of Anchorage was the most efficient terminal for receipt of containerized cargo for Anchorage and the surrounding region. This conclusion appears to be confirmed by commercial decisions driven by market pressures.

4.4 Channel Excavation Alternatives

4.4.1 Channel Depth. The controlling depth across Knik Arm Shoal is 25 ft MLLW. Pilots require 10 ft of gross keel clearance for a safe crossing above the least bottom depth. Sea-Land containerships typically have 32 ft of draft on fully loaded arrival at the dock; therefore, 42 ft of water depth is required for safe passage over tidal shoals. The depth generally available at the face of the dock at the Port of Anchorage is -35 ft MLLW. Less keel clearance is required at rest over the soft bottom at the dock, but because of this, 32 ft draft is a practical maximum for vessels regularly serving the port. The depth of the channel would have to be 42 ft if there were no tide, but since the tides at Anchorage cause a 26- to 29-ft variation in depth twice daily, pilots can now realize 10 ft of keel clearance into the port without any dredged channel. The channel depth criterion becomes an economic choice, related to the expense of waiting for high tide. The computer simulations discussed previously were the principal tool for evaluating various channel depths with regard to tidal delays and related expenses. Knik Arm Shoal is only minutes away from the Port of Anchorage; thus ships generally arrive at the dock at near the same tidal stage at which they crossed the shoal. This fact led to investigation of channel excavations to depths near -35 ft MLLW. Ships' delays were simulated for channel elevations of -30, -35, -37, and -39 ft MLLW. The elevation -35 ft MLLW appears feasible, given other considerations to be discussed below. Further optimization analysis in the feasibility phase may reveal another depth as the true optimum. This appears unlikely to change the depth more than a foot or two from -35 ft MLLW, unless coal ship traffic becomes a certainty before the study is completed. An additional 2 ft should be excavated below the guaranteed depth to allow for irregularities in dredging and inaccuracies in hydrographic surveying. Another 2 feet of excavation provides a means of avoiding annual maintenance dredging. Therefore, to guarantee a least depth of -35 ft at MLLW for 1 year or more, the channel would be excavated to -39 ft MLLW.

4.4.2 Channel Width. Channel width is generally determined as a function of ship beam (maximum ship width). TOTE containerships have beams of 105 ft, and one tanker calling at the Port of Anchorage in 1991 had a beam of 106 ft. Passing traffic at the shoal is easily avoided, so the channel would be designed for one-way traffic. An allowance must be made for maneuvering conditions in the channel with regard to cross-currents, wind, and waves. Another allowance must be made for the limited accuracy of the pilot's ship position with respect to the channel margins. The combination of these factors constitutes the "sweep path" or lane over which some part of a ship may pass in normal conditions. The extreme winter conditions at Knik Arm Shoal call for an additional allowance for the adverse effect of ice on ship navigability and possible concurrent strong winds and low visibility. The buoys marking the shoal are not in place during icy months, so the pilot's knowledge of the location of this hazard is much less precise. An additional width allowance must be made for these extreme circumstances.

Finally, a margin of safety beyond this extreme sweep path must be incorporated. Conservative allowances for each of these considerations led to a width of 800 ft (or 7.5 times the beam), as explained in more detail in Appendix B, Engineering. This width is conservative in terms of major marine fairways around the world (PIANC 1980). However, discussions with Cook Inlet shippers and pilots indicate that 800 ft is a minimum acceptable width during extreme circumstances at Knik Arm Shoal. TOTE representatives suggested 1,000 ft would be best. An additional 200-ft channel width was considered as a means of avoiding annual maintenance dredging, as well as an added safety margin. Therefore, to guarantee a width of 800 ft for 1 year or more, the channel would be excavated to a width of 1,000 ft. No other width alternatives were considered in detail in this study.

4.4.3 Channel Orientation. Findings of the 1992 NOAA survey indicate that a channel positioned along the southern flank of Knik Arm Shoal, as shown in figure 4-4, would have the best chance to avoid encroachment by either North Point Shoal or Woronzof Shoal. The existing Fire Island Range, by visual inspection of 1982 and 1992 contours, appears to be situated along a scouring trend. This route was chosen as the centerline of the proposed excavation, an alignment that is already in routine use. Feasibility study considerations may result in minor adjustment of the centerline bearing or position south of the shoal, but these adjustments are not likely to significantly change excavation quantities or shoaling trends along the channel. Figure 4-5 shows a perspective view of the channel. The initial excavation quantity is estimated to be 353,000 cubic yards.

4.4.4 Channel Maintenance. A suitable open-water disposal area for dredged material lies north of Fire Island in depths exceeding 90 ft, as shown in figure 4-4. Detailed, reliable prediction of the behavior of the channel bottom at Knik Arm Shoal is impossible at this level of study. The physical environment represents a world-class extreme in terms of its complex dynamic behavior. Past analyses and indications of 1992 field data lead to some general conclusions about the evolution of the shoals in the

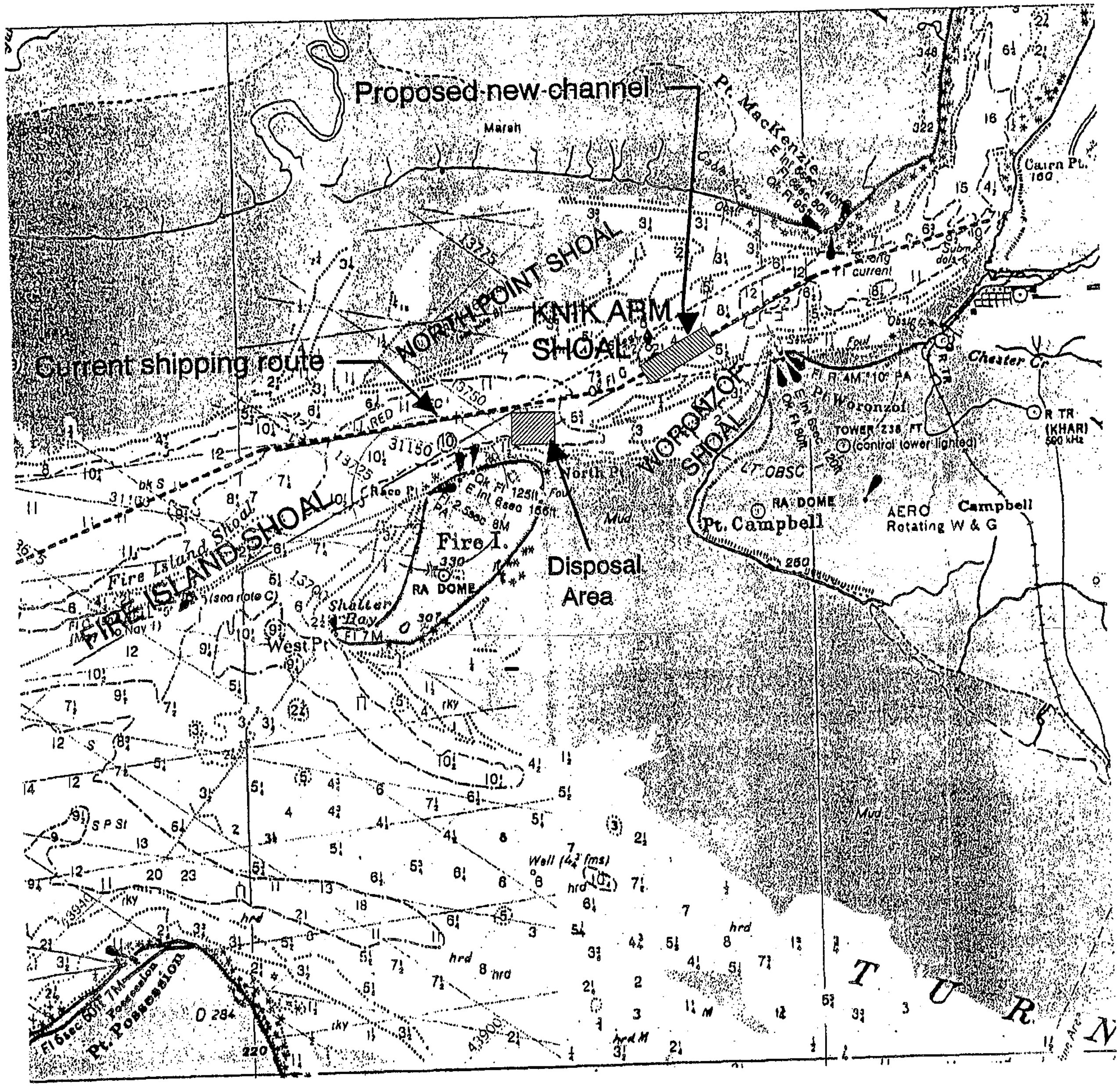


FIGURE 4-4.--Current shipping route in upper Cook Inlet, with proposed channel and disposal area locations.

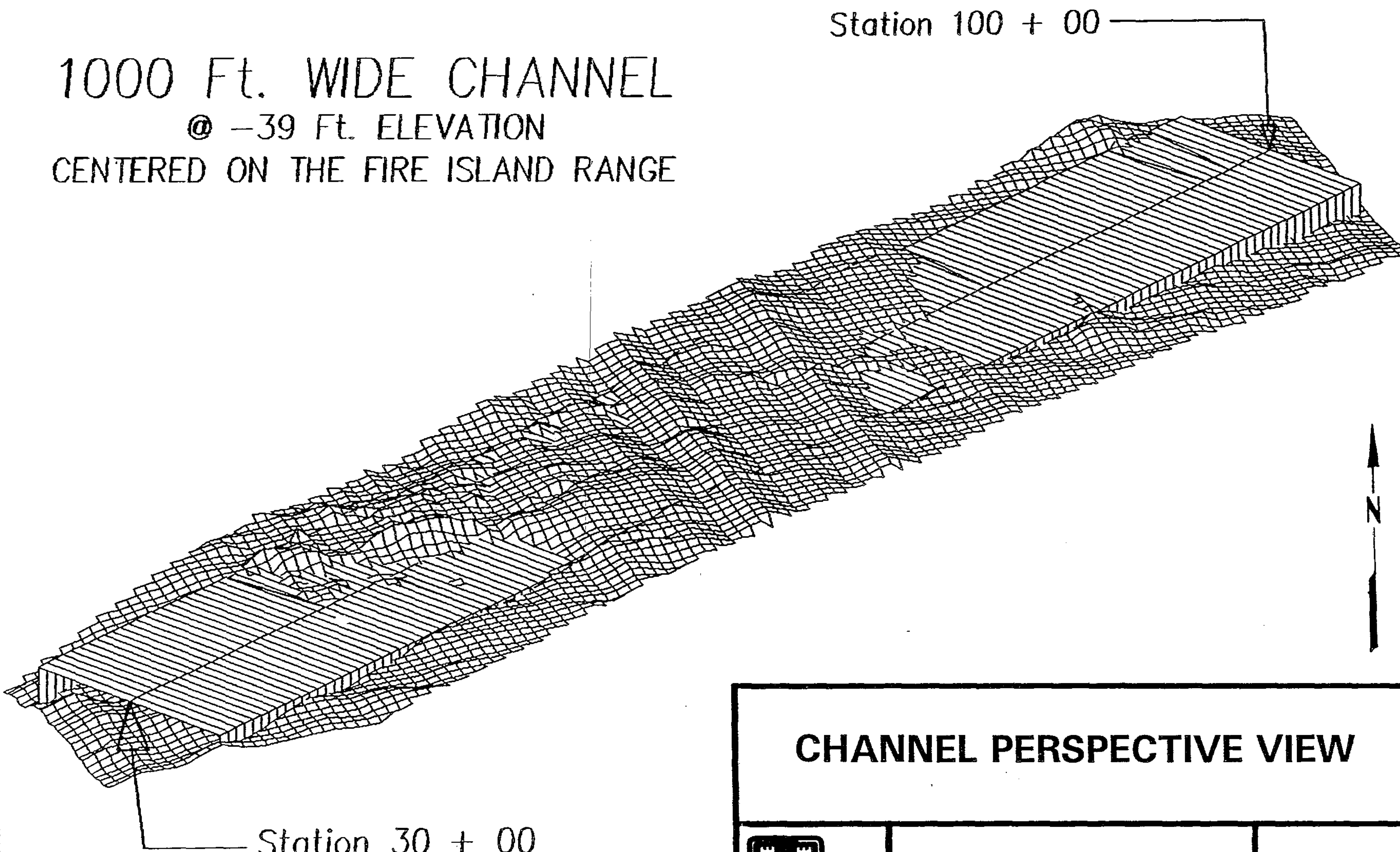
vicinity of the proposed channel. These conclusions were applied to subjectively formulate a set of alternative futures for the channel. The most optimistic of these is for the indications of scour along the channel alignment to lead to long-term stability, following initial excavation of the glacial deposits which control the present natural depths. The most pessimistic future calls for an early major inundation of the channel

125656

1000 Ft. WIDE CHANNEL

@ –39 Ft. ELEVATION

CENTERED ON THE FIRE ISLAND RANGE



CHANNEL PERSPECTIVE VIEW

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by either Woronzof Shoal or North Point Shoal. Both of these scenarios are physically possible, but more likely futures lie somewhere between.

Considering the materials in motion along the bottom and potential sources for excess sediment transport, several intermediate futures were conceived. A slow but steady excess transport of sand off the eastern flank of Knik Arm Shoal could lead to shoaling along the northeastern channel margin. Annual inspection surveys would reveal this trend in time to allow programming of maintenance dredging the following year. Average quantities to be excavated would be on the order of 30,000 cubic yards. This cycle could continue indefinitely, with maintenance dredging every other year.

Figure 4-3 shows a "finger" of sand reaching toward the proposed channel alignment. This extension of Woronzof Shoal could eventually reach the channel margin and provide a supply of excess material within the channel boundaries. This scenario would result in a maintenance dredging cycle equivalent to that previously discussed.

The version of the future finally applied for evaluation of economic feasibility involved the combination of these two intermediate futures, with an additional allowance for channel slope sloughing during the first 4 years. Dredging quantities during the second and fourth years are estimated to be 80,000 cubic yards; the quantity is estimated at 60,000 cubic yards every other year thereafter. This intermediate future appears to be the most reasonable "expected" or "weighted average" prospect to specialists who have studied the site conditions.

4.4.5 Cost Estimates. A number of assumptions were critical to the estimation of dredging costs. The quantities of material to be dredged and the likelihood of encountering occasional cobbles and boulders led to selection of a mechanical clamshell dredge as the most practical excavating tool. This type of equipment is deployed each summer for maintenance dredging at the Port of Anchorage. Stronger currents at Knik Arm Shoal and intermittent strong winds and rough seas would require a heavier clamshell bucket and additional anchors for the dredge. The sandy dredged material and more severe conditions would limit production to a rate about 25 percent less than that achieved in dredging cohesive silt at the Port of Anchorage. Open-water disposal in depths of 90 ft or greater north of Fire Island would be equivalent in operational terms to the open-water disposal accomplished each year offshore of the Port of Anchorage dredging project. The equipment required for dredging Knik Arm Shoal would be suitable for dredging the Port of Anchorage. Therefore, no mobilization or demobilization (mob/demob) costs are necessary for the Knik Arm Shoal dredging. The assumption is that the dredging at Knik Arm Shoal would be accomplished under the same contract as the maintenance dredging at the Port of Anchorage. If the mob/demob costs were shared between the two projects, a reduced cost (i.e., a benefit) for the Port of Anchorage project would result. The effect on the conclusions regarding feasibility is the same for both mob/demob options. The estimated first cost (without mob/demob) is $2,296,000 for dredging a new channel on Knik Arm Shoal. The estimated maintenance dredging costs would total $433,600 in years 2 and 4 and $325,200 every other year thereafter.

5. EVALUATION OF ALTERNATIVES

The alternatives for improving navigation in upper Cook Inlet that were introduced in the previous section are evaluated in this section. Nonstructural alternatives include improved aids to navigation, increased frequency of surveys, modifying shipping practices, and diverting cargo to ports other than Anchorage. The structural alternative is a dredged channel over Knik Arm Shoal.

5.1 Improved Aids to Navigation

5.1.1 Impacts on Waterborne Commerce. The enhancement of pilots' ability to locate their ships with respect to Knik Arm Shoal and other hazards in upper Cook Inlet would reduce risks of grounding and allow some increase in the vessels' speed. Highly accurate ships' positions would not provide major increases in safety or transportation efficiency unless the positions of the hazards were also known with equivalent precision. The U.S. Coast Guard makes every effort within its operational and fiscal capabilities to mark submerged hazards with lighted buoys or by other means. Channel markers are moved from time to time as changes in bathymetry are revealed. Well-marked hazards and precise ships' positions give pilots the information needed to steer a safe course.

Buoys are placed each year on the north and south sides of Knik Arm Shoal but are removed each winter so the ice will not destroy them. Knik Arm Shoal is not marked during winter, when steering conditions and visual means of fixing ships' positions are at their worst. During these periods, pilots must watch their fathometers carefully as they steer the prescribed course past the shoal. Charts of Knik Arm Shoal have been updated about every 10 years, so the latest published soundings have at times been more than 12 years old.

Improvements to the navigational aids (navaids) would reduce the risk of groundings in upper Cook Inlet. The proposed system of DGPS positioning and shipboard ECDIS navigation would provide ships' positions within a few feet of true earth coordinates. The system would not help pilots steer past Knik Arm Shoal with less delay unless the pilots had equally accurate knowledge of the shoal's changing geometry.

5.1.2 Economic Benefits. Improved navaids must be accompanied by more frequent surveys for tangible economic benefits to be realized in the form of shorter passages across Knik Arm Shoal. Otherwise, the navaid refinements would save transportation costs primarily by reducing the risk of collisions with fixed hazards. No further economic analysis was accomplished in this study, since implementation of this plan is not the direct responsibility of the Corps of Engineers.

5.1.3 Implementation Prospects. The U.S. Coast Guard may be relied upon to continuously evaluate the effectiveness of navaids in upper Cook Inlet. The enhancement of existing navaids, such as lights, ranges, and channel markers, and addition of new ones are accomplished by the Coast Guard through plans like the 1991 Waterway Analysis. Establishing DGPS in upper Cook Inlet may require support from outside the Coast Guard. A shore station broadcasting radio telemetry of GPS satellite position parameters would need to be built and continuously operated. The location and design of a DGPS shore station is a specialized challenge. The station would be useful to surveyors over a wide area and potentially to pilots of aircraft. Other more exotic applications exist, including electronic maps in cars, personal GPS receivers, and coordinate-transmitting emergency locator beacons. A number of agencies with interests along these lines could contribute knowledge, funds, or in-kind services toward designing, constructing, and operating a DGPS shore station. This alternative, by itself, is not within the Corps of Engineers authority for navigation improvements, but Corps participation may be possible in an interagency effort to establish regional DGPS capabilities.

5.2 Increased Frequency of Surveys

5.2.1 Impacts on Waterborne Commerce. An increase in the accuracy of pilots' knowledge of Knik Arm Shoal's current geometry would allow wider windows of tidal accessibility through reduced margins of safety. The controlling depth assumed by pilots may now be more than a fathom (6 ft) shallower or deeper than the actual condition along the route prescribed by fixed navaids. This error could be reduced to 2 or 3 feet if annual surveys were accomplished and rapidly transmitted to pilots. This more accurate knowledge of the bottom elevation could eventually allow reduced keel clearances across the shoal.

5.2.2 Economic Benefits. Simulations indicate that the average delay now experienced by containerships would be reduced about a half-hour per voyage if 8 ft gross keel clearance were acceptable. Pilots would probably not accept this clearance in winter under any circumstances. Nor would reduced keel clearance be advisable until the detailed behavior of Knik Arm Shoal and vicinity is more reliably established. At present, the extent of short-term variations in shoal depths is not known. Depths can and probably do vary back and forth many times more than the net variation found by surveys 10 years apart. Annual surveys would be one way to determine the range of depth variations, but would not reveal changes between (monthly) spring and neap tide cycles or between (quarterly) seasons of the year. Without this knowledge, the benefits directly associated with publication of annual surveys cannot be evaluated. Feasibility phase efforts to measure short-term variations and to numerically simulate shoal behavior over many years' time would result in enough information to estimate these benefits.

5.2.3 Implementation Prospects. The standard NOAA chart publication procedure does not accommodate such frequent updates of hydrographic data. A special arrangement with interagency support would be required to accomplish annual surveys. The Corps of Engineers is elsewhere responsible for surveying many miles of waterways where channels are authorized for maintenance dredging. The authority to maintain a dredged channel includes the authority to monitor changes in the channel and to share results of monitoring with the public. A channel at Knik Arm Shoal authorized for Corps maintenance would allow the Corps to perform surveys at Federal expense and transmit survey data to pilots and others. The high standard of accuracy held by NOAA in its survey and charting practices could be met by the Corps in collaboration with NOAA hydrographic survey specialists.

Annual surveys would be a part of any Corps proposal to dredge a channel at Knik Arm Shoal. Any channel geometry would carry a finite risk of shoaling above the authorized depth. The expected dredging requirement would vary with the depth of the authorized channel.

5.3 Modifying Shipping Practices and/or Diverting Cargo to Other Ports

These options can occur only through market pressures. History and recent decisions by shipping companies indicate that the Port of Anchorage will continue for decades to be Alaska's largest transshipment center for containerized goods. The problems associated with containerships crossing Knik Arm Shoal will also continue for decades unless artificial channel improvements are accomplished. There appear to be no practical recommendations for changes in shipping methods or diversions of cargo to other ports which would effectively reduce costs associated with these delays.

5.4 Channel Dredging

5.4.1 Channel Geometry. The formulation of a functional channel design was summarized in subsection 4.4 and is discussed in more detail in appendix B. Many alternate channel geometries are possible, but for a reconnaissance study a subjective choice must be made to limit the resources involved in the analysis. The option of a channel oriented along the existing Fire Island navigation range (a presently used shipping route) has been shown to be near optimum in terms of minimizing initial dredging quantities. Furthermore, this location appears to avoid shoaling trends in adjacent areas of the inlet. The channel width is a practical choice. Channel depth is the only geometric parameter which may vary significantly after more detailed analysis is completed. A single depth alternative is evaluated in this reconnaissance report, but review of all evidence indicates that this depth is near optimum. The initial excavation quantity is estimated as 353,000 cubic yards, which can be excavated for an estimated $2.296 million. Maintenance dredging every other year is estimated to cost $433,600 the first two times and $325,200 each time thereafter.

5.4.2 Economic Benefits. Economic benefits from the proposed channel excavation on Knik Arm Shoal would come primarily from reduction in transportation costs. Cost savings attributable to the channel excavation would result from reduced fuel consumption by ships serving Anchorage, more efficient stevedore scheduling, reduced administrative costs, reduced vessel and port maintenance requirements, and reduced insurance costs. Opportunity cost of time benefits would result from reduced vessel transit times. A detailed explanation of the derivation of these benefits is presented in appendix C of this report. The following paragraphs summarize the procedures and findings of the economic analysis.

Channel benefits were estimated by calculating the transportation cost for both with- and without-project conditions. Historical and existing commodity movements through the Port of Anchorage were examined. A forecast of Port of Anchorage throughput was developed with reference to apparent trends in these statistics and other knowledge of regional economic development. The Port of Anchorage in this analysis is assumed to continue indefinitely as the dominant port of entry for general cargo imports to most of Southcentral and Interior Alaska.

The prospect for additional ship traffic into Knik Arm bound for the proposed coal export facility at Port MacKenzie is noted, but is not directly applied in the analysis at this reconnaissance level. Likewise, the alternate proposal to expand the Port of Anchorage northward for export of coal is noted, but not applied to project total ship traffic. The success of either of these plans would significantly increase the savings realized by the channel and enhance its economic feasibility.

Petroleum tonnage at the Port of Anchorage has recently been of the same order of magnitude as containerized cargo, but a much smaller number of vessel trips per year are involved. Benefits attributable to the transportation of petroleum products are thus much smaller than those from containerized cargo and were not addressed in this reconnaissance report. Table 5-1 is a summary of projected future waterborne commerce through the Port of Anchorage.

The forecast of future waterborne commerce was applied to estimate the composition of the associated future fleet of cargo vessels and the number of trips per year necessary to transport the future commodity flow. The findings of simulations of ship transits into Cook Inlet during 1991, as described in subsection 3.3 and appendix D of this report, were applied to estimate the average delays per vessel trip without the project. The delays per trip which would occur with the channel in place were also estimated. The difference between these two estimates was applied as the transit time savings achieved by excavation of the channel. Incremental costs associated with these time savings for each of the two scheduled container services now using the Port of Anchorage were next estimated as the National Economic Development benefits of the project (table 5-2).

The average annual cost of excavating, monitoring, and maintaining the channel is estimated as $404,000, with an annual interest rate of 8-1/4 per cent. This estimate assumes that all dredging at Knik Arm Shoal would be conducted in conjunction with the presently authorized annual maintenance dredging of the maneuvering area at the Port of Anchorage. Half the mobilization and demobilization for the joint dredging contract is allocated to the Knik Arm Shoal excavation. The estimates for initial excavation and for maintenance of the channel are discussed further in appendix B of this report.

TABLE 5-1.--*Commodity forecast, Port of Anchorage, 1998-2048 (tons)*

Commodity	Base year (1987-1991)	1998	2088	2018	2038	2048
Freight	633	693	771	849	957	1,104
Cement	62,202	68,091	75,768	83,401	94,069	108,511
Iron or steel	100	109	121	134	151	174
Lumber	1,928	2,110	2,348	2,585	2,915	3,363
Petroleum*	1,250	1,368	1,522	1,676	1,890	2,180
Transhipped cargo	6,917	7,572	8,426	9,275	10,461	12,067
Vans, flats, containers	1,238,456	1,355,708	1,508,571	1,660,553	1,872,948	2,160,492
Vehicles	1,987	2,175	2,420	2,664	3,004	3,466
Petroleum, bulk	779,197	852,968	949,144	1,044,767	1,178,398	1,359,312
TOTAL	2,092,669	2,290,793	2,549,093	2,805,903	3,164,794	3,650,668

* Not otherwise specified.

Total average annual benefits are estimated as $899,000, which exceed average annual costs by $495,000. The ratio of benefits to costs is 2.3. The plan therefore appears economically feasible and worthy of further investigation. The most significant uncertainty is in the estimate of maintenance dredging costs.

5.4.3 Environmental Impacts. Suspended sediment concentrations would increase during dredging and open-water disposal, but the ambient suspended sediment concentrations exceed 1,000 mg/l. Natural turbidities in upper Cook Inlet are not much less than those measured elsewhere in the heart of dredged material plumes. Dredging-induced turbidity levels at either the excavation or the disposal site would be rapidly dispersed and would not have measurable impacts on living organisms. Dredged material would be nearly identical in character to natural material at the disposal site. Benthic

TABLE 5-2.--*Total transportation savings (October 1992 price level)*

Category	Average annual equivalent amount
Sea-Land	
Fuel	$108,000
Crew utilization	97,000
Administrative	30,000
Maintenance	5,000
Subtotal	$240,000
TOTE	
Fuel	$196,000
Crew utilization	165,000
Insurance	75,000
Administrative	53,000
Maintenance	5,000
Subtotal	$494,000
Opportunity cost of time	
Cast-off	$27,000
Early callouts	108,000
Aborted callouts	30,000
Subtotal	$165,000
TOTAL ANNUAL BENEFITS	$899,000

organisms are sparse in upper Cook Inlet and would be affected little by this redistribution of bed material. Neither temperature nor salinity would be measurably affected. Dissolved oxygen may be increased briefly in the vicinity of dredged material disposal operations due to air entrained in the transient vertical currents induced by the descending plume. No tidelands or salt marshes are near enough to be measurably affected by the dredging operations. Marine birds and mammals are rarely found in the immediate vicinity of either the proposed excavation site or the disposal site and can easily avoid these operations.

Large-scale changes in circulation patterns induced by channel excavation are more difficult to predict. The outfall of a secondary sewage treatment plant exists on Point Woronzof, about a mile away. Feasibility studies would include numerical simulation of circulation changes which may affect the dispersion of the sewage treatment effluent. Numerical modeling studies would also evaluate potential changes in salinity penetration into Knik Arm and other water quality changes which may be induced by the channel. All effects are expected to be small and without significant adverse impacts.

5.4.4 Implementation Prospects. The implementation of channel dredging is possible through several strategies. A key purpose of this report is to investigate the advisability of further Federal expense and local sponsor contributions toward detailed feasibility studies. The scale of the project, as defined by its initial cost of construction, makes possible two different paths for Federal participation in feasibility studies, project construction, and maintenance. These two paths, congressional authorization and the small project (continuing) authority, are discussed in the following paragraphs. Alternatively, the project could be constructed entirely by local interests.

Congressional Authorization. The present study was authorized by Congress as a part of the Corps of Engineers' "General Investigations" (GI) program. The GI program leads to congressional authorization of a construction project and its subsequent operation and maintenance by the Corps of Engineers. At the end of the reconnaissance phase, a non-Federal (local) sponsor is identified with the authority and financial capability to pay half the costs of the more detailed feasibility phase of study. The program requires that an Initial Project Management Plan (IPMP) be prepared and the terms of a Feasibility Study Cost-Sharing Agreement (FCSA) be negotiated with the local sponsor. The IPMP describes each increment of the feasibility study and itemizes its cost. The contributions of the Federal government and the local sponsor are explicitly defined, including the in-kind contributions of the local sponsor, which may be as much as half the local sponsor's share of the cost. Federal funds must be programmed and appropriated to match the terms of the FCSA. The cash portion of the local sponsor's share for the current fiscal year must be provided before the feasibility study can begin.

The feasibility study would refine economic estimates and thoroughly explore predictions of maintenance dredging requirements and channel-induced circulation changes. Risk and uncertainty analysis of this report's estimates (see appendix C) indicates that less than 10 percent probability exists that the project will not be found feasible. The field data collection, analyses, and report preparation would require approximately 2 years to complete. The Washington-level review process and reporting to Congress could take another 2 years. Congressional action to authorize the project and to appropriate funds could take 2 additional years, though it is possible to complete this in 1 year.

The feasibility study would lead to a report to Congress in response to the study's congressional authorization. The Corps' recommendations would be contained in this report, with the concurrence of the local sponsor. Congress must authorize project implementation and appropriate funds for construction and subsequent maintenance. Another agreement must be executed between the Federal Government and the local sponsor before preparations for construction can begin. The local sponsor must pay 35 percent of the initial cost to construct a deep draft channel as proposed in this report. The full initial cost of the proposed channel is estimated to be $2.96 million; therefore, the local sponsor's share would be $803,600. Construction in this case could take place the same fiscal year funds are appropriated. Maintenance dredging thereafter would be accomplished at 100 percent Federal expense.

<u>Small Project Authority</u>. The initial cost of the proposed channel dredging project is small enough that it would be possible to exercise the Corps' continuing authority for construction of small navigation projects. This authority is contained in Section 107 of the 1960 River and Harbor Act, as amended. The Corps may expend up to 225 percent of the initial construction cost on a channel such as the one proposed here. This amount includes the feasibility study cost, the initial construction cost, and

maintenance dredging costs up to this expenditure ceiling. Once the expenditure ceiling has been reached, the Corps no longer has authority to maintain the project. Maintenance dredging would thereafter be the full responsibility of the local sponsor. An agreement must be executed prior to construction which provides for the local sponsor to pay 35 per cent of the initial construction cost ($803,600) and to maintain the project after Federal authority has expired. Given the maintenance dredging schedule projected in this report, the Federal authority would expire within 10 years or less following construction.

A cost-shared feasibility study is also required under small project authority, whose objectives are the same as those of a GI feasibility study. Should the final feasibility study recommend construction, Section 107 allows the Corps to proceed without explicit congressional authorization. Appropriations for Section 107 projects nationwide have generally been about $10 million a year. This project would have to compete with other worthy projects in the Nation for these limited funds. The potential exists for delays in construction of a year or more if a backlog of projects occurs. Years of rapid shoaling are possible, following expiration of Federal authority, which could bring the annual cost of maintaining the channel to more than $1 million. The local sponsor in this event would probably abandon the channel, and shipping delays would resume.

Construction by Local Interests. Local interests could choose to construct and maintain the channel at their own expense, once the requirements of the Section 404 permit process, NEPA, and other Federal, State, and local regulatory requirements were met. The Corps of Engineers would, in this case, contribute no funds for either channel construction or maintenance dredging. The Corps would conduct no further feasibility studies or other analyses on this project, should the local sponsor prefer this approach.

Comparison of Implementation Strategies. Congressional authorization, for which this report is the first step, would allow the Federal Government to pay half the cost of a feasibility study, 65 percent of the initial construction cost ($1.48 million), and 100 percent of the maintenance dredging cost ($0.3 million to $0.5 million every other year thereafter). Initial dredging would occur 4 or more years after initiation of a feasibility study.

Small project authority would eventually place the burden of maintenance dredging on the local sponsor. Present estimates of maintenance dredging quantities are uncertain. The expected value would require $0.3-0.5 million every other year. Actual values could in some years exceed $1 million, as discussed in appendix B. This level of dredging expense would probably not be affordable and would result in abandonment of the channel and resumption of shipping delays.

Construction of the project without Federal participation could occur as soon as permit requirements are satisfied, probably within 2 years after the process is initiated. There has been no indication by any maritime interest that this course might ever be pursued. The best public service appears to be continuation of studies under the GI authority.

6. LOCAL SPONSORSHIP

6.1 Requirements for Non-Federal Sponsors

The requirements for local sponsors of Corps of Engineers feasibility studies or constructed projects stem from legal requirements most recently established by the Water Resources Development Act of 1986. This act established cost sharing of Corps of Engineers feasibility studies and construction works, as they apply to the proposed navigation improvements in upper Cook Inlet. A local sponsor must be a legally constituted public body with full authority and capability to perform the terms of agreements for both the feasibility study and construction of the project. Private interests may participate with in-kind contributions to the work or direct cash contributions to the local sponsor, assuming the local sponsor's legal constraints allow such contributions. A group of public bodies may formally agree to act as a single local sponsor.

6.2 Prospective Sponsors

Three Alaskan public bodies have a clear interest in the proposed channel improvement in upper Cook Inlet. The Municipality of Anchorage, as the owner and operator of the Port of Anchorage, has the most obvious interest and would experience the most immediate and direct benefits from channel excavation. The Matanuska-Susitna (Mat-Su) Borough also has an interest, primarily through its advanced plans for a new bulk terminal at Port MacKenzie, opposite the Port of Anchorage on the west side of Knik Arm. The Mat-Su Borough also has an interest, as Anchorage's neighbor, in reducing the cost of transportation through the Port of Anchorage. The State of Alaska itself has an interest in upper Cook Inlet channel improvement, because of the regional effect of improved transportation efficiency and the prospect of accelerated export of Alaska's natural resources. The Alaska Department of Transportation and Public Facilities has a longstanding relationship with the Corps of Engineers in this regard, and has for a

The Mat-Su Borough has had discussions with its neighbor boroughs to the north, the Denali Borough and the Fairbanks-North Star Borough, to create a consortium to promote export of natural resources from the three vast boroughs. The best prospect appears to be sponsorship by the Municipality of Anchorage, perhaps with funding assistance from the State of Alaska.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

A Federal interest has been shown to exist in a channel improvement at Knik Arm Shoal. An 800-ft-wide maintained channel at an elevation of -35 ft MLLW would cost an estimated $2.296 million to excavate. Maintenance dredging would be necessary every other year, on the average. Environmental impacts of these potential operations appear minor. The average annual cost of the work is estimated at $404,000. National Economic Development benefits would be achieved in the form of reduced tidal delays to containerships and other deep draft vessels now serving the public Port of Anchorage. The cost savings associated with avoiding these tidal delays appear to exceed $899,000 per year. Benefits for this plan exceed costs by a ratio of 2.3 to 1.

The Municipality of Anchorage has the legal and financial capacity to act as local sponsor of further investigations or of project construction.

7.2 Recommendations

An economically feasible, environmentally acceptable plan for a channel improvement at Knik Arm Shoal appears to have a clear Federal interest. I therefore recommend further investigations in the form of a cost-shared feasibility study.

Date: 5 April 93

JOHN W. PIERCE
Colonel, Corps of Engineers
District Engineer

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APPENDIX A

COORDINATION WITH MARITIME INTERESTS

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COORDINATION WITH MARITIME INTERESTS

When this study started, it soon became apparent that the Corps of Engineers was only one of many agencies, firms, organizations, and groups that shared an interest in Cook Inlet navigation. Two State agencies were studying the inlet's future port needs at the same time, one under orders from the governor and the other from the legislature. The U.S. Coast Guard had just studied the inlet's navigation aid needs, and the National Oceanographic and Atmospheric Administration (NOAA) was planning a hydrographic study. Japanese firms were examining the inlet with a view to exporting Southcentral Alaska coal from a new port at Point MacKenzie in the Matanuska-Susitna Borough. The Port of Anchorage was considering a north expansion for export of bulk materials.

Coordination with all interested groups, then, was an essential part of the study. The effort went far beyond just keeping the public informed. Various public officials, including the governor, mayors, and State commissioners, were informed of the study. Cook Inlet port coordination meetings were held regularly at the Port of Anchorage building. Attendance at the meetings averaged 20 to 30, including participants from throughout Southcentral Alaska, from the 17th Coast Guard District in Juneau, and from NOAA headquarters in Rockville, Maryland.

The Corps study received valuable contributions from those who attended the meetings and others. Many published studies and unpublished data collections by other Federal, State, and local agencies were reviewed. Especially valuable studies were done by the U.S. Coast Guard, the Alaska Industrial Development and Export Authority (AIDEA), and the Alaska Department of Commerce and Economic Development. The NOAA ship *Rainier* provided support for Corps personnel who measured currents and sediments in the upper inlet during the summer of 1992. The Alaska Department of Commerce and Economic Development, which was doing its own port study, contributed to the economic analysis. The Port of Anchorage hosted the meetings and provided records; the major shippers, Totem Ocean Trailer Express and Sea-Land Service Company, provided crucial statistics. Also contributing were the Matanuska-Susitna Borough, the U.S. Coast Guard, the Southwest Alaska Pilots Association, and Elmendorf Air Force Base, among others. Representatives from Seward, the Kenai Peninsula, and Valdez participated. The *Alaska Journal of Commerce* regularly covered the meetings.

1. SUMMARIES OF COORDINATION MEETINGS

a. Meeting at Port of Anchorage, August 14, 1991. Dr. Orson P. Smith, principal investigator in the Corps study, introduced the study to port officials. Other items on the agenda included an update on the NOAA hydrographic study, discussion of a planned oceanographic computer model of Knik Arm, and the status of a proposed coal port at Point MacKenzie, across Knik Arm from Anchorage.

b. First Cook Inlet Port Studies Coordination Meeting, September 16, 1991. This meeting was at the Port of Anchorage Building, as were the similar meetings that followed. This first meeting was attended by representatives of the Corps, the Port of Anchorage, the proposed Port MacKenzie, the State, and Commonwealth North (a business and industry support group). Mr. Tommy Heinrich of the Alaska Industrial Development and Export Authority (AIDEA) was working on a fast-track study for the governor to determine the feasibility of a deep-water port on Fire Island near Anchorage. Plans were made to establish an "advisory committee" for the Corps study and to share bibliographies of previous inlet studies.

c. Cook Inlet Port Studies Coordination Meeting, October 17, 1991. The meeting was attended by 19 persons including representatives from the Corps, the State of Alaska, the Port of Anchorage, the Coast Guard, NOAA, the Southwest Alaska Pilots Association, Coastline Engineering, the Kenai Peninsula Borough, the city of Seward, Port MacKenzie, and Commonwealth North.

Dr. Smith reported that Congress had authorized ~~$438,000~~ for a year-long Corps of Engineers reconnaissance study of Cook Inlet navigation problems. The aim was to find one alternative for channel improvement or breakwaters that looked feasible. The opportunities appeared to be in the upper inlet. We would begin with a thorough literature review aimed at producing a bibliography of all technical material on upper Cook Inlet. We would continue coordination meetings.

Mr. Heinrich of AIDEA reported that the fast-track Fire Island Study was scheduled for completion in December with a budget of $200,000. Governor Hickel intended to purchase 1,200 acres on Fire Island, near Anchorage, for a potential port if the study indicated such a port was feasible. The public and legislators were demanding a public hearing before the State purchased any land.

Responding to the governor's study aimed at Fire Island, the State legislature directed the Alaska Department of Commerce and Economic Development (ADCED) to produce a broad-based analysis of future Cook Inlet port needs. Mr. Jim Wiedeman of the department said the study, with a $200,000 budget, would concentrate on upper inlet ports. The Corps helped develop the scope of work for the economic study and planned to share the results.

Dr. Douglas F. Jones of Coastline Engineering reported that he had received a $45,000 State grant to develop a numerical model of the inlet bottom near the Port of Anchorage, primarily to determine the impact of the port's planned boat harbor project on dredging requirements at the port. The completed model would cost an estimated $500,000; Dr. Jones hoped to obtain funds from his firm, from the Port of Anchorage, and from potential users of the model.

Commonwealth North, a local business-industry support group, strongly supported the idea of a regional port authority, as did the Kenai Peninsula Borough. Mr. Gary Daily, port director for the Matanuska-Susitna Borough, said several Japanese companies were beginning to examine Cook Inlet with emphasis on exporting coal. Ice was their main concern. Commander George Capacci said the U.S. Coast Guard would improve the navigation lights in the upper inlet and modify them to accommodate the more northerly route that mariners use to avoid Fire Island Shoal.

Commander John D. Wilder of NOAA, from Rockville, Maryland, said the 231-foot NOAA ship *Rainier* would be in Cook Inlet in July and August 1992 for a hydrographic survey. Mr. Glen Glenzer, Anchorage port director, said the potential for port development is bigger than the parochialism that has long hampered the area. He urged the group to "think big, and cooperatively."

d. Cook Inlet Port Studies Coordination Meeting, December 3, 1991. This meeting was attended by 23 persons, including representatives of the Corps, the State, the Port of Anchorage, the U.S. Coast Guard, the U.S. Navy, NOAA, the Port of Valdez, the city of Seward, Port MacKenzie, Commonwealth North, Coastline Engineering, and major shippers.

Dr. Smith brought the group up to date on the Corps study. He said the potential opportunities for a project in Cook Inlet would be channel improvements: dredging at the shoals. Field work for the study was to be done in the summer of 1992 from the NOAA ship *Rainier*, which would be on a 3-month visit to Cook Inlet. Dr. Smith described the use of the acoustic Doppler current profiler, which broadcasts acoustic beams that reveal the lateral and vertical motion of currents at various depth levels. He said the Corps would also make computer simulations of ships transiting Fire Island and Knik Arm Shoals, both in the shoals' unimproved condition and with various hypothetical profiles that could be achieved by dredging. He asked for information from pilots and shippers to help with the simulations.

The AIDEA "fast-track" report on the feasibility of Fire Island as a major port would be completed in about a week, Mr. Heinrich said, and would include some technical oceanographic information. Scopes of work had been released for the legislatively mandated ADCED study of Cook Inlet port needs. There was some discussion of the scope for that study's economic analysis, which was developed in cooperation with the Corps of Engineers.

e. Joint Port Commissions Meeting, Port of Anchorage and Matanuska-Susitna Borough, January 8, 1992: Dr. Smith briefed this meeting on the status of the Corps' Cook Inlet navigation study. The annotated bibliography was nearly complete. Plan formulation had begun; Dr. Smith discussed five alternatives being considered. Arrangements to conduct field measurements in the summer of 1992 aboard the *Rainier* had been approved by NOAA's Rockville, Maryland, office. The contract for the economic analysis in the ADCED study, which was developed in cooperation with the

Corps, had been advertised and would be awarded in February. Detailed development of the ship transit time simulations would begin in 2 or 3 weeks.

f. Cook Inlet Port Studies Coordination Meeting, January 28, 1992: Nineteen persons attended, representing the same interests as in prior meetings. Mr. Glenzer, Anchorage port director, began by describing recent and ongoing land acquisitions for port expansion. The port had received 1,420 acres of tidelands north of the port site from the State, and was acquiring about 10 acres of fill property from the Alaska Railroad in a land swap.

Dr. Smith discussed the Corps study, saying the formulation of the ship transit computer program had begun. The purpose was to determine the time and costs involved in waiting for tide on Fire Island and Knik Arm Shoals. The simulations, he said, would first take a *status quo* year, then a year with a hypothetical 45-foot-deep channel. The study also would look at possible future changes and increases in cargo, such as coal export. Maintenance dredging requirements are difficult to estimate, he said, and constitute a major technical question of the study. He described these alternatives being considered: (1) a channel across Knik Arm Shoal; (2) a channel across Fire Island Shoal, either the north or the south route; (3) deepening and expanding the Port of Anchorage; (4) managing an area for Point MacKenzie port development; and (5) access to the proposed Fire Island port. The 1-year reconnaissance study might recommend a full-scale feasibility study, he said, which would take 3 years. The earliest construction date would probably be 1998.

Mr. Daily, Matanuska-Susitna Borough port director, summarized efforts under way to establish a port for bulk commodity export at Point MacKenzie. A railroad spur to the port would be necessary.

The Fire Island port study done at the governor's request had concluded that the feasibility of such a port was questionable. A "peer review" panel was being assembled to review the results. The State had delayed a decision on purchasing land for the proposed port until the review was completed.

Mr. Wiedeman of ADCED reported that the low bidder, ECO Engineering, Inc., had been selected as contractor for the State's Southcentral ports development study. Other bidders were appealing the decision.

The Coast Guard had added two radar transponders in the upper inlet. Surveys would be completed in about 2 months to relocate the Race Point Range to avoid Fire Island Shoal, Commander Capacci reported.

Mr. Pat Beckley, regional planner with the Alaska Department of Transportation and Public Facilities, said his agency had begun to develop a long-range harbor system plan.

g. Cook Inlet Port Studies Coordination Meeting, March 18, 1992: Approximately 22 persons attended, including representatives of all major Cook Inlet shippers. Mr. Rich Wilson attended from the Southwest Alaska Municipal Conference (Ports Alaska). U.S. Navy Captain Bob Baratko attended. The Fire Island study was in the final stages of peer review; the review results had not been released. The Mat-Su Borough was said to be advertising for a consultant to design a Point MacKenzie port. The borough had scheduled public forums on the construction of a railroad spur to the port.

Dr. Smith gave a briefing with handouts on the Corps study. He explained the computer program to simulate journeys of ships through upper Cook Inlet to approach the Port of Anchorage. One page of the handout was on studies of currents in Cook Inlet. The DYNINLET one-dimensional model, similar to other computer models used to determine flood plains for flood insurance studies, showed remarkable consonance with other measurements. Cook Inlet was to be the test case for implementing this model in ocean studies.

Dr. Smith described the Global Positioning System (GPS) that would be used by the NOAA research ship *Rainier* in upper Cook Inlet in the coming summer. Corps researchers planned to be on board July 15-24. Dr. Smith suggested that interagency support might bring about a permanent GPS shore station for use by pilots and surveyors.

Mr. Ted DeBoer of Totem Ocean Trailer Express, a major shipper, suggested that the Corps study include the cost of extra equipment, such as trailers, that freight companies must buy because of the tidal constraints on entering and leaving Anchorage.

The ADCED study was having problems with the contract award. Mr. Wiedeman said a decision was due on a contractor appeal within 10 days.

h. Cook Inlet Port Studies Coordination Meeting, May 7, 1992: This meeting, with approximately 28 persons attending, was a busy one. Seven different reports were heard on studies or development projects under way in Cook Inlet.

Dr. Smith presented preliminary results of the economic part of the Cook Inlet study, based mainly on the numerical simulation of ships navigating the inlet. The analysis so far indicated that shoal channels would not justify their cost with present cargo volumes. The infusion of large coal-carrying ships could change this conclusion, Dr. Smith said.

Contractor appeals on the ADCED study were settled, and the firm of Peratrovich, Nottingham and Drage was selected to do the study. Mr. Eric McDowell of the McDowell Group in Juneau would be in charge of the economic analysis and would serve as study manager.

Peer review of the AIDEA Fire Island study found the original cost estimates high but also found the original revenue projections optimistic. The review agreed with the conclusion of the original study, that the revenue from such a port would not justify its cost. The full development alternatives were estimated to cost more than $1 billion. The State decided not to purchase the 1,200 acres offered for the port.

Mr. Daily reported on the status of the Port MacKenzie project. Preliminary cost estimates were complete. Various routes for the rail spur to the port were being evaluated; the recommended route was opposed by area homeowners. Meanwhile, two Japanese freight lines stated that they would commit ships to the port. Pacific International Terminals, a coal terminal operator, was studying the feasibility of Port MacKenzie. Two remaining questions were (1) the effect of such a port on Air Force communications, and (2) the effect of the State mental health lands dispute on the startup of area coal mines.

The Port of Anchorage could offer an alternative coal port by filling tidelands that it had received from the State next to the port, Mr. Glenzer said. Filled land and/or a long dock on pilings would be needed for deep-draft vessels to reach the port. A Department of Army wetlands permit would be required.

Dr. Jones of Coastline Engineering was working on a computer model of circulation and sediment transport near the Port of Anchorage. The Coast Guard had improved the navigation aids and still planned to move the Race Point Range north. Several comments were made about the dynamic nature of Cook Inlet and the idea that construction in one area or for one project could influence other areas of the inlet.

i. Cook Inlet Port Studies Coordination Meeting, August 4, 1992: Approximately 18 persons attended this meeting. Dr. Smith described the July survey mission in Cook Inlet aboard the NOAA vessel *Rainier* to take acoustic and oceanographic measurements. Two Rainier crewmembers attended the meeting; Lieutenant Commander Mike Brown explained the NOAA survey work.

Major findings of the survey:

(1) Sediments on shoals west of Anchorage consist of sands or coarser material; the fine material typical at the Port of Anchorage does not settle in these areas.

(2) North Point Shoal is moving south and has merged with Knik Arm Shoal.

(3) The northern shipping route, or Point MacKenzie Range, is becoming shallower, while the depths on the southern route are almost identical to 1982 depths.

(4) The controlling depth across Knik Arm Shoal is 25 or 26 feet.

(5) The top of Knik Arm Shoal appears to be rock.

Lieutenant Russell Lockey of the U.S. Coast Guard said the Coast Guard was considering moving the Race Point Range to better guide ships around the shoal. A copy of the NOAA findings was to be furnished to the Coast Guard.

Mr. Don Dietz of the Port of Anchorage reported on the port's expansion plan, known as the North Tidelands Expansion. The port was planning to expand incrementally into approximately 1,400 acres north of the port that was being acquired from the State. Improving the transportation corridor into the port was part of the plan.

Dr. Jones updated the group on the circulation and sediment transport model that his firm was preparing in cooperation with the Port of Anchorage through a grant from the Alaska Science and Technology Foundation. Much more financial support was needed; the University of Alaska had not shown as much interest as expected.

Regarding Port MacKenzie, Mr. Daily said the study by the coal terminal operator was still inconclusive. The main concern was whether the needed traffic (volume of coal) would be there. Two to three million tons per year would be needed to make the project viable, the consultant studying the matter believed. Daily also said the possibility of importing pelletized iron ore at Port MacKenzie and turning it into iron briquets for export was being explored by Midrex, a North Carolina subsidiary of Kobi Steel of Japan.

Mr. Chris Gates of the Port of Seward said his city had commissioned its own study of potential bulk movement through the Seward port. He estimated Seward's coal capacity at 10 million tons per year, and maintained that improving the rail connection between Seward and Anchorage would not be as expensive as some of the other projects being considered to facilitate coal shipment. Mr. Tom Brooks, Chief Engineer of the Alaska Railroad, said the railroad could haul several times the current volume of coal to Seward, even though steep terrain and severe weather present operating problems.

Dr. Smith planned to meet with railroad officials for information on the costs of various bulk transportation scenarios.

j. Cook Inlet Port Studies Coordination Meeting, December 4, 1992: Approximately 25 persons attended this meeting, the main purpose of which was to hear the preliminary conclusions of the Corps' Cook Inlet navigation study. Dr. Smith presented the conclusions in a talk with transparencies and other illustrations, acknowledging help the Corps had received and calling the effort "a truly extraordinary example of public service and cooperation."

The study recommended dredging a channel 1,000 feet wide to a depth of -39 feet MLLW on the south side of the Knik Arm Shoal. Benefits of the channel were estimated to exceed its costs by a factor of 2 or more; that is, the benefit-to-cost ratio of the project was estimated at 2 or better. Due primarily to new economic information provided to the Corps by major shippers, including data on planned ship purchases, coal export was no longer believed to be necessary for the project's feasibility.

The quantity of material that would be dredged initially was estimated at 353,000 cubic yards. Maintenance dredging of 80,000 cubic yards was tentatively predicted in the second and fourth years of the project, with 60,000 cubic yards every other year thereafter.

Dr. Smith described two options for continuing the study. The first would be to continue the present congressionally authorized study. The NOAA measurements would be repeated five times during the feasibility stage to more precisely predict maintenance dredging requirements. The total study cost was estimated at $1,478,000. The local sponsor's 50-percent share would be $739,000; half of this could be in-kind services. Dredging could begin no sooner than the summer of 1998. The Corps would be responsible for maintenance dredging.

The second option would be to use the small navigation project authority, Section 107 of the River and Harbor Act of 1960, as amended. The alternative would be cheaper ($500,000 study cost) and faster (construction in 1996). Maintenance dredging by the Federal Government, however, would stop when a funding limitation is reached. The Federal Government would stop maintenance dredging when expenses for that purpose equaled 2.25 times the project's initial Federal cost, or about $5 million. Dr. Smith estimated that the Federal dredging funds would last until about the year 2000, after which the local sponsor would have total responsibility for dredging.

The next steps, Dr. Smith said, are to prepare the study report and find a local sponsor. The sponsor may be a local or State government or a consortium of several governments.

Dr. Smith gave this same presentation to a joint meeting of the Matanuska-Susitna Borough Assembly and the Borough Port Commission on December 5, 1992, to a meeting of the Anchorage Port Commission on December 9, 1992, and to Mr. Tom Fink, mayor of the Municipality of Anchorage, and Port of Anchorage officials on February 4, 1993.

k. Other Meetings. Although this summary contains most of the major meetings that have involved the Cook Inlet Navigation Study, it is not a complete list. Dr. Smith has told and continues to tell the study's story to interested persons and groups. A slide presentation has been prepared to facilitate explanation of the effort and its conclusions.

2. SELECTED NEWS ARTICLES RELATED TO THE STUDY

The Corps' Cook Inlet Navigation Study and related studies of Cook Inlet port needs drew interest from the local media. The *Alaska Journal of Commerce* covered port news and the coordination meetings consistently. Most of the articles included here are from that publication. Other newspapers and magazines, however, including the *Anchorage Times*, the *Anchorage Daily News*, *Alaska Business Monthly*, the *Seward Phoenix Log*, the *Frontiersman* (Matanuska-Susitna Borough), and *Marine Digest and Transportation News* also covered these issues because they were important to Alaska's still-developing economy.

The articles that follow in this section are selected from many that appeared during the course of the reconnaissance study.

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CORPS SEEKS TO ORGANIZE PORT STUDIES

By Margaret Bauman
Alaska Journal of Commerce

Upper Cook Inlet, potential home of at least two new ports, is being eyed for so many studies the U.S. Army Corps of Engineers says an organized effort is needed to avoid expensive duplicated efforts.

"We wanted to get all these groups together to share the information," said Carl Borash, chief of the corps' plan formulation section in Anchorage.

"We found out about seven different types of work going on in Upper Cook Inlet, related to evaluation of ports and navigation needs," said Borash in the wake of a meeting last week at the corps office at Elmendorf Air Force Base.

The meeting was called by Orson Smith, who will direct a $435,000 corps study, to begin in October, on navigation of Upper Cook Inlet.

The studies in progress and in the planning stages range from a $200,000 assessment of constructability, markets and finances by one state agency, to the corps' navigability study.

Prompted by Gov. Walter J. Hickel's move to acquire Fire Island acreage for the state, the Alaska Industrial Development and Export Authority is seeking a firm to do an assessment of constructability, a market study and a financial feasibility analysis of a major deep water shipping facility at Fire Island. So far 16 outfits have picked up copies of the proposal, said Tommy Heinrich, project manager for the $200,000 AIDEA project. Heinrich said he expects probably half a dozen of those who made initial inquiries to seek the job.

AIDEA asked that only firms with extensive port facility ex-

Continued on Page 8

Corps

Continued from Page 1

perience and a comprehensive background in the marketing potential and financial feasibility of a port of the proposed size apply by the Sept. 17 deadline.

The state Department of Commerce and Economic Development is talking about doing a needs assessment of Upper Cook Inlet, said Jim Wiedeman, development specialist with the department. "We have not written any guidelines for the project yet," he said, adding that the agency hopes to complete the study by the end of fiscal 1992.

The Corps of Engineers, meanwhile, has $435,000 in federal funds for a study to begin in October on navigation of Upper Cook Inlet. "We can get additional funds for the following fiscal year if we need to finish up with some items," Borash said.

The corps study will investigate the merits of federal works such as dredged channels and breakwaters, with emphasis on the needs of deep draft vessels and related waterborne commerce, said Col. John W. Pierce, district engineer for the corps, in a letter to Hickel.

"All related previous work by the Corps of Engineers and others will be evaluated and synopsized in our first report," Pierce said. "The report will also estimate the potential regional economic benefits of the navigation improvements from the proposed port developments at Point MacKenzie, the Port of Anchorage, Fire Island, and potential sites in the Kenai Peninsula Borough. Transshipments from interior Alaska and other regions will be considered."

The first report from that study is scheduled for completion in November 1992.

The draft report on vessel operations in Cook Inlet is due out at the end of September from the Cook Inlet Regional Citizens Advisory Council Prevention, Response, Operations and Safety Committee.

The $10,000 study has been in progress several months, said Lisa Parker, executive director.

The study will examine traffic and berthing problems, the need for additional navigation aids and vessel traffic lanes, Parker said.

The same organization is also planning an annotated bibliography of information on Cook Inlet, plus a directory that lists everything from the names of contractors and permits required for all shipping facilities ever built on Cook Inlet to a list of pipeline and platforms along that body of water, Parker said.

"We want to learn the construction costs, where and who built what, production rates, the whole shooting match," Parker said.

The meeting at Elmendorf was timed well for the corps, which is just getting its funds, Borash said. "We have been talking with the other agencies by phone for a month or two, but when you get together you can pass documents around. You can flush out information you can't get on a one-to-one one phone call," he said. "We are going to try to meet on a regular basis, to accomplish what the people of Alaska need to have done for the future."

Representatives of proposed ports at Fire Island and Port MacKenzie were present at the session, along with representatives of the Port of Anchorage.

"I was really tickled to hear all this was going on," said Gary Daily, maritime consultant and port director for the proposed Port MacKenzie. "As long as we have these things all working at the same time, I want to be sure these reports are coordinated by a respected nonpartisan individual. It was nice to have Orson Smith call the meeting and it clearly showed the state's willingness to work with this. Nobody wants to get sideways of each other because we are all friends and we all work with each other."

Japanese firms also are studying or planning to study the inlet's problems and potential and it is important that the American and Japanese reports be useful to each other, he said.

The meeting brought together a lot of players, who agreed to work together and support each other. One thing the group agreed on was to meet regularly to keep abreast of who is studying what and what further studies are planned.

"There is a variety of agencies who have agreed to share information, to even share resources if they have to, to make this study come out and happen," said Roger Graves, governmental and environmental affairs manager for the Port of Anchorage. "It was a meeting of the minds to agree to work together. This time they are going to work together and this is a very positive step. It's a big enough project that all of these various agencies and the state and municipal entities work together they will get the best bang for the buck."

The meeting brought together a lot of players, who agreed to work together and support each other, he said. One thing the group agreed on was to meet regularly to keep abreast of who is studying what and what further studies are planned.

"We want to look at it from a broader perspective," Borash said. "We will look at it from a national economic efficiency point of view, which combination of proposals would provide the most economic efficiency for the nation, for exporting of natural resources. The existing port at Anchorage is accommodating the normal day to day commodities for southcentral Alaska, but they are basically maxed out on space and they don't have the facilities for handling the existing coal. It either has to go to Seward, or a new port has to be developed."

Borash continued: "Port MacKenzie is the potential one. They have their permits in line and they feel they are on the threshold of implementing coal export from there."

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FORUM/ LETTERS

To AIDEA: Go slow on port, coordinate studies

By ARLISS STURGULEWSKI

COMPASS
POINTS OF VIEW FROM OUR COMMUNITY

"Let's hit a big one for Wally!" appears to be the rallying cry at the Alaska Industrial Development and Export Authority, one of the state's major development agencies.

I can only hope they settle down enough to coordinate their efforts with the plethora of at least six other extensive and expensive efforts being undertaken, work that should have a direct bearing as to whether we say yes or no to this major potential project.

AIDEA has entered into a hasty contract with Cook Inlet Region Inc. to buy part of Fire Island. AIDEA's Board, utilizing a limited competition procurement process, has entered into another hasty contract to perform an assessment of the constructability, market, and financial feasibility of a deep water port at Fire Island. They have set a short 45 days to complete what amounts to a very major task.

But a number of other activities are taking place in Cook Inlet, all of which common sense dictates should be coordinated with and be part of any activity AIDEA undertakes and any decision it makes.

The legislature made available $200,000 to the Department of Commerce and Economic Development for a deep-water-port study for Southcentral Alaska. The legislature's intent is that this study evaluate and compare locations in the Cook Inlet region for expanded port capacity.

The Department of Commerce is in the process of moving ahead on this legislatively directed study through a normal bidding procurement process. The work program will extend well beyond the Fire Island study. Obviously this has major implications for the Fire Island port.

The Corps of Engineers has an allocation of $435,000 to cover a navigation study of upper Cook Inlet. It anticipates looking at Anchorage, Point MacKenzie, Fire Island, Beluga, the Kenai Peninsula and, if need exists, the Homer port. It is taking a good look at bathymetric and other studies to see what potential future Corps projects need to be considered for the upper Cook Inlet area.

I've been told by Corps spokesmen that economic issues, market supply and demand, and transportation issues will be included as well. The Corps study, to begin soon, will be of a year's duration followed by six months of public comment and revisions. This too has major implications for any port at Fire Island or elsewhere in Cook Inlet.

The Port of Anchorage has done extensive work on, and continues to study, tidal influences. Shouldn't this information be part of any assessment of the technical aspect of building a port at Fire Island?

The Mat-Su Borough has on board an experienced port director and is determining the feasibility of a port on the Point MacKenzie side of Cook Inlet. The borough has gone out of its way to cooperate with the Municipality of Anchorage in the development of its feasibility plans. It is imperative we consider its findings when discussing a port in Cook Inlet.

It looks to me as though we are going to be spending in excess of a million dollars in studies by various federal, state and local agencies to answer some very basic questions. What's technically feasible? What impacts might there be with development? Which ports should be created, altered or expanded?

In heaven's name, if we're going to spend over a million dollars, why is AIDEA rushing ahead doing their Fire Island thing? AIDEA, as the state's representative, should be taking the lead in working and coordinating its schedule with the other agencies so we end up with some real answers.

I did hear the Corps is making a major effort to pull the agencies together and I applaud its efforts, but the state should show more leadership and good sense.

Before AIDEA rides off in all directions, let's look at what we are doing to our neighbor to the north, the Mat-Su Valley, valiantly trying to develop a reasonable economic base.

Let's look at the whole of upper Cook Inlet. Let's look to see that the public comment process is honored. If Fire Island is a great project, it's going to be a great project in a year's time. With cooperation we'll have a far better answer to the question, Fire Island: Yes or No?

☐ Sen. Arliss Sturgulewski is a member of the state Senate

Legislators wary of Fire Island proposal

By Bob Tkacz
For the Journal of Commerce

For the second time in barely five weeks the House and Senate transportation committees have cast wary eyes toward Hickel administration construction proposals.

This time the subject was port development on Fire Island or elsewhere in Cook Inlet.

Paul Fuhs, Division of Economic Development director, found himself defending the credibility of a yet-to-be-completed feasibility study on Fire Island in light of Gov. Walter J. Hickel's strong public support for a port facility there and a recent memorandum of understanding for a state purchase of land there.

The memo also drew questions on a second more general port feasibility study not expected to be completed until late spring.

In October the same committees questioned Department of Transportation proposals for new road construction. Some legislators view those budget request previews as ill-planned and coming at the expense of needed maintenance on existing state roads. In particular they complained that the Department of Transportation's use of road maintenance funds for construction of a new highway to Cordova was improper. Attorney General Charlie Cole said, at the Nov. 21 meeting, that work this past summer apparently constituted a misdemeanor violation of state law. Cole was to name, Wednesday, a special prosecutor to investigate the question and to file and prosecute any charges he saw fit.

Fuhs, also at the recent session, emphasized that Hickel is viewing the Fire Island proposal strictly as "a business decision." "If the project doesn't make economic sense we're not going to build it," the governor declared, according to Fuhs.

Early on in the session he explained as a "misunderstanding" a recent Anchorage Daily News report suggesting Hickel was interested in relocating the southern terminus of the natural gas pipeline in which he is an investor from Valdez to Fire Island.

"That is not an administration proposal," Fuhs said. The reporter had asked what types of projects would be needed on Fire Island to make construction of a shipping terminal there a profitable venture and Fuhs had answered only that major developments like the gas pipeline would be necessary, he explained.

Anything from large construction project pieces such as preformed concrete or steel bridge sections to bulk commodities like coal, crude or refined oil and timber would be shipped from a Fire Island port through the governor's proposal. The 3,600-acre island is located about three miles west of Anchorage International Airport. Under a September agreement signed with the Cook Inlet Region Inc., Native corporation the state would immediately pay $1 million for 200 acres on the island and another $5 million by 1993 for an additional 1,000 acres.

Coming after the Cordova road matter, legislators were asking whether this agreement reduced both studies to little more than political fig leaves meant to hide the administration's latest attempt to circumvent legislative procedure as well as political opposition.

Sen. Curt Menard, D-Wasilla, said he was "irritated" by the Fire Island study which came "out of the ozone" to the front of the administration's Cook Inlet priorities without awaiting the results of the regional inquiry.

Sen. Arliss Sturgulewski, R-Anchorage, charged that the administration was leaving local and borough governments out of its planning and called for a policy group for more comprehensive and coordinated efforts.

"If you're going to lead a parade you've got to bring the band behind you and that band's not there right now," Sturgelewski said.

She questioned several aspects of the Fire Island proposal and said it was premature for planning on a specific project until answers were forthcoming.

Among the questions Sturgulewski noted were potential problems with ice build-up in the inlet, the prospects for expansion of the existing Port of Anchorage, and the lack of any commitments from coal mines to use a Fire Island terminal.

Fuhs defended the letter of intent as a precaution to protect the right to a land purchase for the state in light of the cost of the feasibility studies.

"There have been no conclusions made in advance on any of this. I wouldn't approach it this way," Fuhs said.

Sturgulewski nonetheless warned of "trouble" without full involvement of potentially affected communities. She said Seward officials are "scared to death" that their money-losing port facility would be further hurt by new loading docks nearer to developing coal mines. They were also present to express their own fears.

"If the numbers aren't cooked you will see there is no justification for additional port facilities in Southcentral," declared Seward port manager Chris Gates. The west shore Kenai Peninsula port has "millions of tons of capacity" for shipment of future coal mines, and could grow from its current 3.5 million ton per year capacity to five millions with minor changes.

"We have a port that's highly underutilized," Gates said.

Following a presentation by Mat-Su Borough promoters of their own port facility at Point Mackenzie, just two miles from the Anchorage airport, Gates said, "There's a lot said that's

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Fire Island

Continued from Page 2

flat wrong."

The Mat-Su Borough has spent over $1.5 million on construction of a road to the inlet and related development and earmarked more than $160,000 in additional funds primarily for promotion of their port proposal. But the idea was called "speculative" by a Massachusetts consulting firm that questioned whether it could ever turn a profit. In 1989 Mat-Su voters rejected a proposal to float $50 million in bonds to construct the project.

The project, including 5,000 acres for future expansion — or for stockpiling of coal when ice prevents ships from reaching any Upper Cook Inlet port, said borough ports director Gary Daily. Despite other estimates he said the port is projected to earn almost $4 million per year for half a decade and $6.5 million annually thereafter while costing $18 million to build.

Sen Pat Pourchot's D-Anchorage. question whether the feasibility studies would allow lawmakers to compare "apples to apples" was underlined after Daily said his figures were based on $2 per ton wharfage fees and Alaska Railroad vic president Dick Knapp said Seward's 22.5-cent per ton fee did not include capital investment recovery.

Daily could not provide a direct comparison of wharfage fees between Point MacKenzie and Seward when asked to do so by Rep. Gene Kubina D-Valdez.

Corps considers new channel for Cook Inlet

By Margaret Bauman
Alaska Journal of Commerce

Navigation studies under way in Cook Inlet by the U.S. Army Corps of Engineers will determine whether the corps pursues an additional three-year, $2 million study on possible dredging of a new channel.

A $438,000 corps study to be completed by November 1992 will include a set of alternative channel, maneuvering area and breakwater improvement designs, including estimates of initial construction costs and maintenance expenses.

Limited measurements of currents, suspended sediment concentrations and bottom materials also are to be gathered for preliminary assessment of channel stability.

Plans also include a regional economic baseline analysis with preliminary estimates of origin-to-destination cargo transportation costs over existing maritime routes and over routes with proposed improvements, said Orson P. Smith, project director.

If the more extensive study were recommended, local sponsors would have to bear 50 percent of the costs, Smith said. Given positive results and no major controversy, initial dredging of a channel could take place no sooner than 1998, he said.

In conjunction with this study, the corps has asked the state Division of Business Development, Department of Commerce and Economic Development, to pursue specific related economic data. The economic portion of the project, under the direction of Jim Wiedeman, is to be completed around April, Smith said.

The cooperative effort frees up about $50,000 for further technical studies that would not be in the budget without the cooperation of the state agency, he said.

The corps also is negotiating with the National Oceanic and Atmospheric Administration to undertake studies this summer on currents and channel stability . The work would proceed aboard a NOAA survey vessel to be stationed in Cook Inlet. NOAA scientists will be doing hydrographic studies, surveying shoals and approaches to the Port of Anchorage. Point MacKenzie and Fire Island. Smith said.

"Our interest is in designing a navigation channel across these shoals," Smith said. "To do this we need to know how much maintenance dredging will be required. We spend about $2 million a year dredging the Port of Anchorage. For us to charter a ship and go out and do it ourselves, it would have been essentially financially impossible."

Interest in an economically feasible channel has been heightened by the prospect of coal exports from the Wishbone Hill mine, owned by Idemitsu Corp., a Japanese corporation.

"It's a darn interesting project, with the prospects for coal exports real, tangible at this time," Smith said.

While the state has between one-third and one-half of the nation's coal reserves, "Alaska coal is not currently competitive in world markets," noted Steve Minor of Waterfront Marketing, who is actively supporting a proposed facility at Port MacKenzie, across the inlet from Anchorage.

"Activities during the next 10 to 12 months will determine whether Alaska can capture these new competitive export opportunities, including coal from new mines and increased production from existing mines," Minor said.

"We're going to take a closer look than we have before at existing cargo and consumer goods now coming into Anchorage and calculate how much time would be saved for the ships to cross the shoals over the dredged channel rather than wait for the tides to come in," Smith said.

The cooperative study for Upper Cook Inlet was initiated during the fall when the corps sought an organized effort to avoid duplication.

MARINE DIGEST

AND TRANSPORTATION NEWS   FEBRUARY 1992   VOL. 70, NO. 6 $3.00

NEWS LOG

Rail link sought for proposed Port MacKenzie

By Margaret Bauman

ANCHORAGE - Developers looking for an economical way to bring natural resources to port from Alaska's interior are waiting to see who builds a rail link to the proposed Port MacKenzie. The rail link, critical to the port's potential, would run some 30 miles from Palmer to the proposed port on Upper Cook Inlet.

Before lending support to that line, railroad officials need to know what revenues would be generated by the port, said Loren Lounsbury, chairman of the board of the Alaska Railroad Corp. Even if the railroad did lend support, the corporation doesn't propose to finance it, Lounsbury said.

According to Dick Knapp, vice president of marketing for the railroad, track construction and installation costs of $1 million to $3 million a mile is an investment that simply couldn't be paid off in the 15-year life of the Wishbone Hill mine, a critical part of the project.

On the other side, port promoters from the Matanuska-Susitna Borough say they have the economic facts and numbers needed, except those they need from the railroad to complete the project.

In the middle are the natural resources developers of coal and timber, who say lower costs of transporting the resources are critical to give them a competitive edge.

"What we are talking about is the development of resources of interior Alaska," said Steve Minor, port marketing specialist for the Matanuska-Susitna Borough. "Coal is just the immediate thing we can look at, measure and build into our economic models.

"The state has already identified more than 100 commercially viable mineral deposits along the rail belt corridor which are easily accessible. Those mines and those forests are not now open because we can't be competitive in our transportation costs."■

Wishbone's wish

A key player in the proposed Port MacKenzie construction is Idemitsu Kosan Co. Ltd., the largest independent oil company in Japan. Idemitsu Alaska, Inc., a subsidiary of Idemitsu Kosan, wants to develop the Wishbone Hill coal fields for export on the world market.

That development hinges, among other things, on the cost of getting Wishbone Hill coal on board ship.

Idemitsu's own analysis of the physical acceptability of Cook Inlet to the large ships needed to haul the coal was to be completed at the end of January.

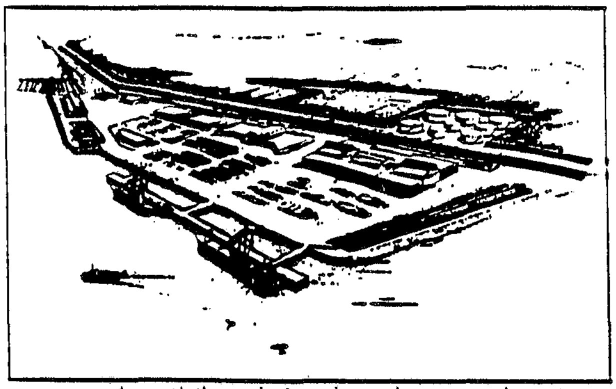
Present projections are for one million tons of coal a year to move out of the mine for 15 years. The two market windows for coal Idemitsu has determined are 1995 and 1998.

Southcentral Ports Polish Expansion Plans

Other regional competitors regard Fire Island port development as cause for concern.

By Douglas Schneider

Gov. Walter Hickel's plan to turn Anchorage's Fire Island into a megaport – from which Alaska's vast deposits of coal, timber, fish, gravel, petrochemicals and other products would find a fast track to world markets – has thrown several neighboring Southcentral communities with port plans of their own into a race to develop the state's next major seaport. Which city ultimately wins depends on how much each port costs, the needs of industry and the dictates of nature.



An artist's rendering shows the proposed Fire Island port complex.

A supporter of huge capital projects, Hickel has long dreamed of turning Fire Island into a world-class seaport. Such a port, according to Paul Fuhs, senior legislative liaison and formerly the state's director of economic development, would open up Alaska resources and create thousands of new jobs.

In November, Hickel administration officials announced they had reached an agreement with Cook Inlet Region Inc. (CIRI), the Native regional corporation that owns Fire Island, to buy 200 acres of real estate on the island's west side for $1 million. The sale is contingent on the outcome of a state feasibility study of the site. Should the location prove acceptable, the state would have the option to buy up to 1,200 acres of additional CIRI land holdings on the island.

But rather than widespread support, Fire Island has sparked mostly fireworks. Critics say upper Cook Inlet is a nightmare for ship navigation, and the cost, estimated at between $500 million and $1.8 billion, is too steep. Most vocal have been a host of Alaska communities that say pouring so much state money into a new port project would disrupt their own port expansion plans, plans that each view as far more practical.

Wishbone Wishing. Northeast of Palmer lie the untapped, high-quality bituminous coal deposits of Wishbone Hill. Largely owned by the Japanese resource-development company Idemitsu-Kosan, Wishbone Hill could produce some 1.5 million tons of coal each year – if only developers could find an inexpensive way to get the coal to markets.

Gary Daily, port director for the Matanuska-Susitna Borough, thinks he has the answer. "Alaska's minerals are source competitive, but not transportation competitive," Daily says. "The idea is to get the coal to the closest deepwater port, dump the coal into ships and come back for more. Our Point MacKenzie is the closest deepwater port."

Located about three and one-half miles northwest of Anchorage on the north shore of Knik Arm, Point MacKenzie would be the hub for Wishbone Hill coal, Daily says. Point MacKenzie also would ship resources extracted from along the Railbelt, such as Interior coal from Usibelli Coal Mine in Healy and timber harvested from forests around Fairbanks and Nenana. Last year, some 1 million board feet of Interior timber were brought south on the Alaska Railroad. Gravel and limestone might also have market potential through Point MacKenzie.

The Mat-Su borough would be hard-pressed to find a better spokesperson for its port dreams. Daily soothes his skeptics with a sales pitch woven with a deep, charismatic voice finely tuned from a career in radio. It's convincing, polished. Adding heft to his remarks is Daily's long association with harbor development.

Daily first served as Homer's harbor master and later as port director, a job he held for 10 years. In 1987, Daily became Dutch Harbor's port director and oversaw more than $100 million worth of new development in the form of bottomfish processing plants and expanded docking facilities. These days, Daily touts the advantages of Point MacKenzie as the state's next major port.

"Point MacKenzie has 5,000 acres of land to work with," Daily says. "Dredging isn't required, according to our engineers, and the preliminary dock engineering studies have been done. The road to MacKenzie is in. It's gravel, but it is in."

Port development is halted by uncertainty surrounding a final settlement of Mental Health Trust land claims near the proposed mine site. More important, the borough needs a railroad link to the proposed port. About 30 miles of rail from the port to the Alaska Railroad main line near Houston would cost $50 million, according to Alaska Railroad officials.

Where the money would come from to build the rail spur is a question that has yet to be answered. Chances are, the state would be asked to help. "If the state is going to be behind the export of Alaska resources, then we need the state to be an active participant," Daily says.

As far as financing the port itself, one option being considered is for the Mat-Su borough to issue revenue bonds, with repayment guaranteed by industry. "We think it may be something like what we did in Dutch Harbor, where we worked with industry to secure funding, but did not put the burden on the taxpayer," Daily explains.

So far, Mat-Su has spent about $750,000 on the project, mostly for feasibility studies and permits. Final cost of the Point MacKenzie port is expected to be at least $20 million.

Seward's Nightmare. Point MacKenzie's dream of shipping Wishbone Hill and Usibelli coal have caused nothing but nightmares for Seward's port marketing director, Chris Gates. "If they are successful, there will be no more coal shipped through Seward, and we will lose everything we have spent so much time and money to build," Gates says. He adds that past state investments and commitments to Seward's port development would be jeopardized by a new port.

None too happy about the prospect of losing Usibelli's business to Point MacKenzie and eager to cash in on as much of Alaska's resource export trade as possible, Gates has launched his own campaign to promote Seward's underused port facilities and the city's potential for growth. And a good salesman he is. Articulate and experienced, Gates boasts training in transportation and logistics from the University of Tennessee. He took over the marketing and development reins at the Port of Anchorage in 1978.

With Gates' help, Anchorage in the early 1980s convinced Korean importers that coal could be shipped from Alaska year-round. To prove it, the Port of Anchorage in 1983 loaded 20,000 tons of coal into an ore ship in the dead of winter and sent it to Korea. Gates made his point. Ironically, Gates suggested in a 1981 Anchorage port development master plan that Fire Island would be a good site for a port.

In 1986, Gates became Seward's port marketing director and set out to transform the fishing- and recreation-based community of 5,000 into the state's only coal port. Helped by Korea's Suneel Alaska Corp.'s 10-year contract with Usibelli Coal Mine, Seward now ships 700,000 to 800,000 tons of subbituminous coal, worth some $30 million, to Korea each year. Seward was chosen over Anchorage because its ice-free, deepwater port is more dependable throughout the year and can handle even the largest ships, Gates says.

But the deal hasn't brought economic nirvana to Seward or Suneel, he explains. In fact, Suneel only has been able to pay its port operation expenses and has yet to make payments on the $25 million in revenue bonds issued to pay for port improvements and coal-loading equipment.

To make port operations profitable, Suneel and Gates are counting on Wishbone Hill coal and increases in Usibelli production. "The plan has always been for Wishbone Hill to use Seward," Gates says. "We have tremendous excess capacity here. If we had Wishbone, we could turn a profit and be competitive."

Gates takes issue with Point MacKenzie's claims that it is the best place to ship coal, even if it is 132 miles closer to Wishbone Hill than Seward. "To think that Southcentral Alaska needs another duplicative, expensive port built on the wrong side of a growing underwater mountain of silt – and usable only nine months of the year – is ridiculous," Gates says. "We believe there is not enough bulk commodity to support both ports and that it would be unwise for the state to spend money on a new port when it has one set up already."

Fire Island Plan. While Seward and Point MacKenzie brawl over the merits of their ports, the creme de le creme in the race to be the first with a megaport is Hickel-backed Fire Island. A 4,200-acre hunk of real estate, most Alaskans see Fire Island during takeoffs and landings at Anchorage International Airport. No one lives on the spruce-covered island; it's used mostly during the summer by commercial and subsistence setnet fishermen.

The idea of turning Fire Island into a megaport has been kicking around since the 1940s. It's now an idea whose time has come, according to the Hickel administration's Fuhs.

"Anchorage has a 9 percent unemployment rate," Fuhs says. "We have problems with our fishing industry and timber industry. I don't know where the revenue is going to come from to replace Prudhoe Bay. The problem for Anchorage is what are we going to do if Fire Island is not accessed."

Fuhs says Fire Island is needed to replace Anchorage's present port near Ship Creek. The port's 130 acres are stretched to the limit. With nowhere else to go, the Anchorage Port Authority supports the Hickel Fire Island plan, albeit reluctantly, according to insiders who wish to remain anonymous.

And what a plan. Hickel administration officials portray Fire Island as a one-stop shopping center for Pacific Rim nations seeking Alaska resources. Fish, coal, timber, gravel and copper from a still-on-the-drawing-board mine near Lake Iliamna would find their way to overseas markets through Fire Island.

Federal law currently prohibits the export of unprocessed North Slope crude oil. But to get around the ban, refineries envisioned on the island would turn the crude into gasoline, jet fuel and other petro-products. Cook Inlet crude, which is not subject to the ban, also would be refined at Fire Island.

Hickel's dream for Fire Island is not limited to just Alaska exports. His plan includes setting up huge warehouses to serve as temporary storage for Alaska imports and pass-through container freight bound for the European and the emerging Soviet markets. Fuhs' own dream of opening a northern shipping route through the polar ice edge to Europe would use Fire Island as a staging area.

"We've had interest expressed from companies to build icebreakers, oil modules, prefab concrete and value-added fish-processing plants," Fuhs says. "Some of these companies are interested in the proximity of the island to the airport, in that they can bring goods in by sea and ship them out by air."

If built, a Fire Island port would serve as the Hickel administration centerpiece for revitalizing the Alaska economy as North Slope oil production declines, state officials say. But its budget-busting cost, estimated at $500 million to $1.8 billion in a recent feasibility study done for the Alaska Industrial Development and Export Authority (AIDEA), may deter its development.

Tommy Heinrich, AIDEA project manager for Fire Island, says the study considers prospects for its development to be "marginal at this point." Heinrich adds, "But that's not my decision to make. The decision rests with the AIDEA's board of directors, not me."

Upper Cook Inlet. Although ships routinely ply the upper Cook Inlet waterway, the area isn't exactly an easy sail. The factors that may make or break port development in upper Cook Inlet have little to do with economics.

"Cook Inlet is a nightmare for ships," says Thomas Royer, oceanographer and sea-current specialist at the University of Alaska Fairbanks, School of Fisheries and Ocean Sciences. "The currents in upper Cook Inlet reach six knots, and ice the size of small ships comes barreling down upper Cook Inlet. Six-knot currents in a port are horrendous. You've also got silting. The place is fraught with problems."

Indeed, upper Cook Inlet's broad tidal flats are a haven for mud and ducks, not for ships and freight. The unstable goo also may cause problems for engineers attempting to span a causeway between Fire Island and west Anchorage. On the deepwater side of the island, the bottom is covered by shifting silt.

"Absolutely, silting is going to be a problem," says Tyler Jones, a former Anchorage port director. "There's a deep channel on the west side of Fire

Island because the water goes through there real fast. Structures, like docks, placed there are going to accumulate silt. It's a big problem that the feasibility studies will have to address."

For Point MacKenzie, the problem may not be mud so much as ice. Each winter, upper Cook Inlet is choked with ice. Ship navigation becomes treacherous. Point MacKenzie could be shut down, just when their Asian clients need the coal most.

"We are looking at the possibility of operating the port only nine months a year," says Point MacKenzie's Daily. "We don't think ice will be a problem if we can stockpile the coal and get it shipped out before the water freezes."

Resolution. Probably neither Hickel's political will nor Daily's charmed radio voice will determine where the next major port will go. Rather, the stark realities of commerce are likely to set the course, according to Tom Dowd, professor of port and marine transportation management at the University of Washington and Alaska's Sea Grant Marine Advisory Program specialist on the nation's port industry.

Unimpressed by Hickel's plans to develop Fire Island, he believes the project is far too expensive when other locations show more promise and make better sense. "You don't want to haul heavy, low-value bulk resources any farther than you have to," Dowd says. "And it seems to me you don't want to haul noisy rail cars through the middle of Anchorage. To me, it makes ultimate sense to make Point MacKenzie the port for bulk exports and the Port of Anchorage the receiving port for containerized imports."

The prospects for development of each port are expected to be discussed in the state's $165,000 feasibility study of Southcentral ports, due out in summer 1992. In the meantime, each community says it will continue with development plans.

Seward, with millions already spent on a new port, is confident of a favorable outcome. "I believe if the numbers aren't cooked, the studies will find no justification for any new Southcentral Alaska ports," Gates says. ❖

Douglas Schneider is a science writer with the Alaska Sea Grant College Program, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks.

Alaska Journal of Commerce
February 17, 1992

Corps begins Cook Inlet study

By Orson P. Smith

The Alaska District of the U.S. Army Corps of Engineers has begun a one-year study of potential channel improvements in upper Cook Inlet.

This study may recommend more detailed analysis which could lead to federal participation in deep-draft channel excavation across Knik Arm Shoal or Fire Island Shoal. Other possibilities include federal participation in dredged maneuvering areas at a Fire Island port, Port MacKenzie, or an expanded Port of Anchorage.

The Corps of Engineers, known to many simply as "the Corps," has for over 200 years worked to make the nation's waterways safe for navigation. Congress has granted the Corps increasing responsibility for channel improvements since the days of the pioneers' westward push along the rivers of the Lower 48. The navigation authority of the Corps has always been limited to construction of breakwaters, channels, and maneuvering areas. Today, excavation of major new channels must be preceded by a two-phase study of estimated life-cycle costs, economic benefits, and environmental effects.

The present study in Cook Inlet is in its first phase, termed the reconnaissance phase, which is 100 percent federally funded. In this phase, scheduled for completion in November 1992, the Corps will endeavor to identify a federal interest in one or more alternative navigation improvements in Cook Inlet. If at least one alternative appears feasible — that is, its long-term economic benefits exceed its costs and the environmental effects appear acceptable—the Corps will initiate a more complex cost-share feasibility phase study.

The scope of the Cook Inlet study includes compilation of a bibliography of prior investigations and technical references. The draft version already exceeds 400 citations and is still growing. Some limited field data collection will take place during the summer of 1992 to assess channel shoaling trends for estimation of maintenance dredging costs. A set of alternate channels will be designed, and the cost to excavate and maintain each will be estimated. The effect of each alternative on the cost of shipping will be assessed through computer simulation of ship transit times up and down Cook Inlet, with and without proposed channel improvements. Present port capacities and proposed improvements will also be considered, along with the option to ship some cargo through ports outside Cook Inlet, such as through Seward, Whittier, or Valdez.

Public involvement in the reconnaissance phase of the Corps study is focused on regional maritime interests of both government and private en-

Transportation/Fishing

Corps of Engineers conducts Inlet study

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terprise. Several Cook Inlet navigation studies coordination meetings have taken place for the purpose of coordinating otherwise independent studies being conducted by various agencies. Those represented at these meetings include the Southwest Alaska Pilots Association, Sea-Land, Tote, Foss, Commonwealth North, the Port of Anchorage, the Matanuska-Susitna Borough, the Kenai Peninsula Borough, the Port of Seward, the Port of Valdez, the Alaska Department of Commerce and Economic Development, the Alaska Industrial Development and Export Authority, the Alaska Department of Transportation and Public Facilities, the Coast Guard, NOAA, the Navy and the Corps. An extraordinary spirit of cooperation has developed among these organizations as a direct result of the meetings.

Discussions at the coordination meetings have resulted in two significant collaborative efforts which will enhance the quality of the Corps study. Various maritime interests, led by the Port of Anchorage and the Matanuska-Susitna Borough, requested a new hydrographic survey of shipping routes in upper Cook Inlet. The National Oceanic and Atmospheric Administration has scheduled its ship Rainier to perform a survey during the summer of 1992. The Corps requested support from the Rainier to make specialized measurements of channel shoaling parameters. NOAA has agreed to help the Corps with these measurements, which will use special-purpose acoustic devices to measure currents and sediment load. NOAA's Atlantic Oceanographic and Meteorological Laboratory in Miami and the Corps' Coastal Engineering Research Center in Vicksburg, Miss., will assist the Alaska District with the measurements.

Photo by Pat Richardson/Corps of Engineers

Orson Smith

The state, through ADCED, was formulating the scope of its Southcentral Ports Development Project in October 1991 when the Corps study began. ADCED subsequently incorporated suggestions from the Corps in its plan of study, which will compile data on historical waterborne commerce and port capacities in a manner compatible with Corps procedures. This information will be provided by ADCED for application by the Corps in economic benefit analyses. This accommodation by the state of Alaska will allow the Corps to use funds for additional measurements in Cook Inlet, which otherwise would have gone toward economic data collection. The projections of future cargo throughput and recommendations for port development made by ADCED will be of interest to the Corps, but federal guidelines for economic benefit analyses require the Corps to make independent projections.

The Corps has looked at feasibility of upper Cook Inlet dredged channels several times in the past, without recommending excavation. The present study will apply 1990s' technology to the question, but the outcome will probably hinge on whether economic conditions have significantly changed since the previous analysis. The serious prospect of coal exports in the near future from an upper Cook Inlet port may make enough difference to warrant further analyses in a subsequent detailed feasibility study.

The feasibility phase will require about 3 years to complete and cost on the order of $2 million, half of which must be provided to the Corps by a local sponsor. The local sponsor may be a city government, a borough, the state of Alaska, or some consortium of public entities. Half of the local sponsor's share of the cost may be provided in-kind, that is by direct participation of the local sponsor's employees or contractors in the study process.

The feasibility phase could be completed in May 1996, if it is recommended by the Reconnaissance Report and funded by May 1993. The conclusion of the feasibility phase is a report with recommendations through the Secretary of the Army to the Congress. The Congress must act to authorize the proposed project and must separately act to fund its construction. This process takes a minimum of two years. Therefore, given positive study results, no major controversy, and prompt action by Congress, channel excavation could begin as soon as 1998. This seems an intolerably long time, but we must remember that the Corps dredging at the present Port of Anchorage followed this course, as did recent harbor works at St. Paul Island and pending construction of erosion control on the Homer Spit and breakwaters at Kodiak.

The Corps is a public service agency with a proud slate of successful Alaska port and harbor projects. The Corps must take a national perspective in evaluating proposals for new works. The evaluation of proposed channel improvements in Cook Inlet will be through, objective, and useful to Alaska maritime interests, no matter what its conclusion. The remarkable cooperation of these interests offers the best chance possible for an affirmative conclusion.

Orson P. Smith, a civil engineer with the U.S. Army Corps of Engineers Alaska District, is the manager for the study discussed in this article.

Thursday, April 9, 1992, The Anchorage Times

Shipping firm to study feasibility of port at Point MacKenzie

TIMES VALLEY BUREAU

PALMER — An international shipping company plans to study the economic feasibility of the proposed port near Point MacKenzie.

The Matanuska-Susitna Borough Assembly passed a memorandum Tuesday night directing the borough manager to enter a contract with Pacific International Terminals. The company will do the study at no cost to the borough.

The borough hopes to build a deep-water port near Point MacKenzie to ship bulk commodities to world markets. Proponents of the project say the port would decrease overland transportation costs, and allow Alaska to be competitive in the international coal market.

Representatives from the company contacted borough officials in December. They visited the proposed port site in February and told borough officials the project was technically feasible.

The study is expected to take 90 days to complete.

MARINE DIGEST
AND TRANSPORTATION NEWS
MAY 1992 VOL. 70, NO. 9 $3.00

AK coal port contest emerging

By Margaret Bauman

ANCHORAGE—Potential coal ports are popping up everywhere as port developers seek alternative cargoes in Alaska's oil-based economy. Even Roberts Bank's Westshore Terminals, in partnership with Stevedoring Services of America, is getting into the act by studying a possible coal port at Point MacKenzie.

But departing port director Glen Glenzer is betting on a coal port closer to home, at the tidelands north of the Port of Anchorage. Glenzer, a retired Navy aviator who has served as port director since January 1990, said he feels the tidelands have great potential. He's working with military officials to determine if the site would cause any problems for adjacent Elmendorf Air Force Base.

"A port is supposed to be a service to the community," Glenzer said. "If we are going to stay competitive in energy production and resource development, we have to have a world class port capable of exporting those resources. In order to become other than completely oil dependent, we have to develop resources and the most evident in the interim is coal."

Across Cook Inlet, three miles from the present Port of Anchorage, lies Point MacKenzie. Officials of the Matanuska-Susitna Borough, based in Palmer, said they planned to sign a contract shortly with Pacific International Terminals to determine the feasibility of a coal terminal at Point MacKenzie.

"They have 90 days to do it at their expense," said Steve Minor, a port marketing specialist. "Assuming the study shows Port MacKenzie is feasible by their measure, they will have a two-year option to become a joint venture partner."

PIT is a joint venture of Westshore Terminals at Roberts Bank, B.C., the second largest coal terminal operator in the world, and Stevedoring Services of America.

"We believe they can do it and they are pretty optimistic too," Minor said.

Glenzer, meanwhile, is boasting the advantages of the tidelands, which he says would require only three miles of railroad to link up with coal cars coming from the railbelt area. And Panamax-sized vessels could come in at a flood tide, he said.

Glenzer argues that the tidelands would be more economical than Port MacKenzie, where a 30-mile rail link would be needed, but Minor says that area poses many problems.

"You have wetlands, national security problems and, are you really going to stockpile coal near Government Hill (a residential area) which already has benzine problems?," he asked. "The Westshore folks say when they do a coal terminal you don't want the stockpiles less than two miles from a residential area, and that would be right next door."

Another port source, speaking on condition that he not be identified, said a major problem was the Air Force antenna farm, a very sensitive area of electronic equipment used by the National Security Agency, Navy Security Group Activity and the Air Force 6981st Electronic Security Squadron. "They are very sensitive to electromagnetic interference, so they are particularly sensitive to development in the North Tidelands," the source said.

Still another port source questioned the financial feasibility of the tidelands, estimating it would cost $25 million just to build up the surface needed for the coal terminal and storage areas.

Glenzer acknowledged that such a facility could have a devastating effect on Seward, which houses the state's only coal terminal. "But we should and could work together," he said. ■

Transportation

Glen Glenzer

Photo by Margaret Bauman

Anchorage port director will switch to tidelands

By the Alaska Journal of Commerce

Anchorage Port Director Glen Glenzer will be moving to new waters May 15, as he steps down from his port post to begin a development project at the tidelands north of the port for Mayor Tom Fink.

Glenzer, a retired Navy aviator who has served as port director since January 1990, said he felt the tidelands had great potential as a coal port. He is working with military officials to determine if the site would cause any problems for adjacent Elmendorf Air Force Base.

"A port is supposed to be a service to the community," he said. "If we are going to stay competitive in energy production and resource development, we have to have a world class port capable of exporting those resources. In order to become other than completely oil dependent, we have to develop resources and the most evident in the interim is coal," he said.

Across Cook Inlet, three miles from the present Port of Anchorage, lies another proposed coal and natural

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Alaska Journal of Commerce
May 4, 1992

Glenzer will seek coal port for Anchorage

Continued from Page 24

resources port, at Point MacKenzie. Officials of the Matanuska-Susitna Borough, based in Palmer, said they will sign a contract shortly with Pacific International Terminals to determine the feasibility of a coal terminal at Point MacKenzie.

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Still another port source questioned the financial feasibility of the tidelands, estimating it would cost $25 million just to build up the surface needed for the coal terminal and storage areas.

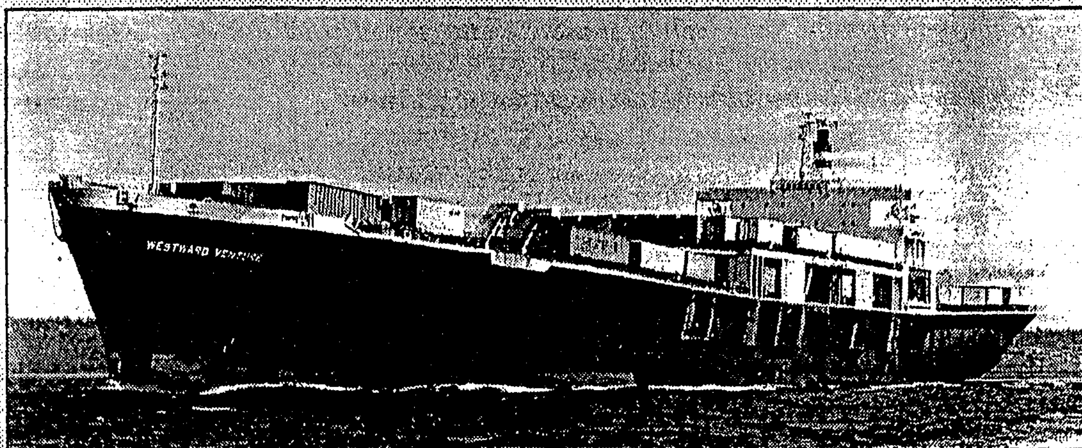
Glenzer acknowledged that such a facility could have a severe effect on the economy at Seward, which houses the state's only coal terminal, "but we should and could work together," he said.

Glenzer, whose last official day as port director is to be May 15, retired after 30 years in the Navy, as a captain, in June 1973. He became manager of the Alaska chapter of the Associated General Contractors of America, Inc. In 1983, he was named deputy commissoner of the northern region of the state Department of Transportation and Public Facilities.

Prior to serving as port director, he was director of public works and executive manager of general government operations for Anchorage.

Incoming port director Don Dietz, is a former commander-in-chief Pacific Fleet and staff electronic warfare officer at Pearl Harbor.

May 4, 1992 Alaska Journal of Commerce



S.S. Westward Venture Photo courtesy TOTE

TOTE expands midship

By Margaret Bauman
Alaska Journal of Commerce

Totem Ocean Trailer Express, Inc. would put a third ship in seasonal service in Alaska next summer, if market conditions warrant, says Robert B. McMillen, president and chief executive officer.

TOTE is negotiating in Jacksonville, Fla., with American Shipbuilding to lengthen the 700-foot S/S Puerto Rico, to be renamed Northern Lights, by 90 feet, to accommodate TOTE's shipping capabilities, McMillen said.

Once the mid-body is constructed, the ship will be cut in half to fit the new section in. Estimates are the reconstruction phase will take a total of about four months, officials said.

The addition of the Northern Lights to Alaska routes could increase TOTE's market share, but more importantly it will give TOTE leeway for some major rehabilitation needed on its two existing ships, which are 17 years old, officials said. Over the next few years, The Great Land and Westward Venture, TOTE's other two ships, are to undergo modernization which will add 15 to 20 years of service life to each. Two years ago, TOTE's Great Land ship had flooding problems which took the ship out of commission for 96 days, officials said.

"The Northern Lights will not only provide the backup capability we need to assure a steady shipping schedule to our customers, but will be available to handle the anticipated increase in Alaska trade into the next century," McMillen said.

TOTE, a privately owned Alaska corporation headquartered in Seattle, is a subsidiary of Totem Resources Corp., which also owns Foss Maritime Co. and InterOcean Management Corp.

The Frontiersman - Friday, May 8, 1992

Assembly agrees on alternative port corridor

By SANDRA MEDEARIS
Frontiersman reporter

The Mat-Su Borough Assembly Tuesday night approved in concept a railroad corridor from Houston to a proposed port at Point MacKenzie.

The tracks to carry coal from the proposed Wishbone Hill mine to the port would follow a course designated as Corridor 4A. This route is preferred by people who protested Corridor 5, the route favored by port planners following a study by Peratrovich, Nottingham, and Drage Inc.

There was a collective sigh of relief following what Borough Manager Don Moore described Wednesday as a "crescendo of cooperation" on the route.

Favoring development and a strengthening of the Valley economic base, but not through his back yard, Brian Kincaid said that he could live with Corridor 4A.

"I feel refreshed that the system has worked and I feel refreshed because of the forum we've been allowed," said Kincaid, who lobbied vigorously against Corridor 5, which runs past his house.

"I think what we're hearing is that the desires of the public could be met by Corridor 4A," said Don Moore, borough manager. The engineers were told to do a "tabletop analysis," and pick the best route on that basis, Moore said.

"The public hearing process goes to the sociology of the question and the human process," said Moore.

But Roy Carlson, the public works director, said the route was not drawn in indelible ink, but approved in concept.

"The corridor is a concept, not a detailed route. We are saying this is about where the route should go. It can move to the right or the left depending on people impact, environmental impact, and engineering considerations."

Route 4 A proposed Alaska Railroad Spur would have the same terminals in Houston and Point MacKenzie as the previously planned route, but is a direct route which will run to the west of Flat Lake, Horseshoe Lake, Crooked Lake, and the Papoose Lakes and their recreationally sensitive and inhabited areas. Less wetland is impacted.

Property owners, many from Anchorage, have offered vigorous protest at six borough hearings against having the railroad run through their back yards to destroy a peaceful and quiet retreat and intended retirement homes.

Alaska Journal of Commerce June 29, 1992

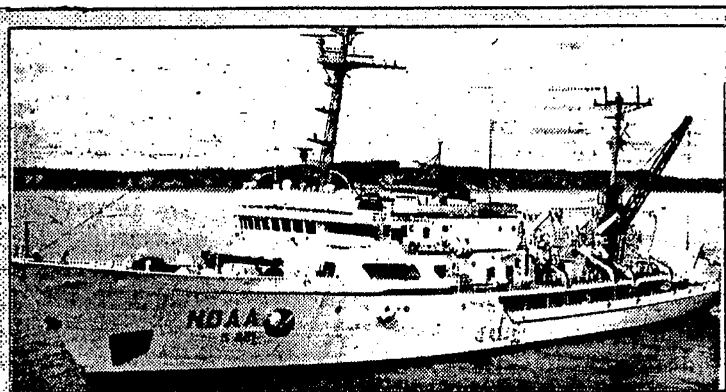


Photo by Margaret Bauman

NOAA survey ship Rainier in Cook Inlet

Inlet survey will aid shippers

By Margaret Bauman
Alaska Journal of Commerce

Bathemetry studies under way in Upper Cook Inlet by the National Oceanic and Atmospheric Administration will determine the economic feasibility of increased commercial traffic in these waters.

"It's one of the highest priority projects we have been on for a long time," said Captain Thomas Richards of the NOAA scientific research vessel Rainier, whose crew will be mapping the depths of Upper Cook Inlet through mid-August. NOAA scientists aboard the Rainier will be joined in July by a team from the U.S. Army Corps of Engineers, brought in from several states to look for extremes and variability in sediment concentrations and bottom characteristics, said Orson P. Smith, a civil engineer in charge of that project.

Without the cooperation of NOAA, these crucial studies would not be financially feasible, Smith said. "Our first report is scheduled to be completed in November, but we may get to go on," he said. The second report would be a cost-shared feasibility study, based on whether or not there is a potentially economically single alternative for channel dredging, he said. "The corps report in November will conclude whether further studies are warranted with regard to channel dredging," he said.

The South Central Port Study, now under way by the Anchorage firm of Peratrovich, Nottingham & Drage, is looking at all existing and proposed port development in

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Inlet studies vital to future port, shipping expansion

Continued from Page 1

Cook Inlet, to project future cargo demand, and draw conclusions on where best sites for future port development lie.

The corps used $495,000 included in federal energy and water development legislation for its navigational studies, with the bulk of the funds going into related economic studies being done by the Alaska District of the corps.

Preliminary findings of the corps study indicated dredging shoals in upper Cook Inlet to improve marine navigation might not be economically justified unless cargo shipments increased dramatically. To determine whether the benefits of shoal dredging would justify the original and maintenance costs, the Anchorage office of the corps put together a computer simulation of ships navigating Cook Inlet.

The Rainier, with a crew of 63, operates in Alaska at a cost of $15,000 to $20,000 per day, employing a Global Positional System to determine exact locations and side scan sonar to map obstacles potentially hazardous to marine traffic in Upper Cook Inlet.

The Rainier is presently the only one of four NOAA ships assigned to the West Coast of the United States in operation because of funding priorities, Richards said. Given the funds needed, NOAA has about 30 years of studies still to do in the Aleutians and probably 30 years of work in Prince William Sound and between Nome and Bristol Bay, Richards said.

"The toughest part is the turpidity of the water, the high current, high tide and the fact that things are changing all the time," Richards said. "We'll start at Anchorage and head toward the Beluga shoal."

Capt. Thomas Richards, in command of the Rainer — Photo by Margaret Bauman

GPS, developed by the Defense Department at a cost of over $12 billion, uses satellites and computers to compute positions anywhere on earth. In the case of Upper Cook Inlet, it can aid in mapping areas to tell navigators exactly how far they are from a specific hazard, from sub-surface boulders to shoals.

"GPS is almost brand new to the east and west coasts," Richards said. "They have been putting satellites up in space, but there have not been enough satellites above the horizon for us to use for navigation. Each year we are putting up one or two more satellites. We still need the one shore monitor station," he said.

A secret to accuracy of the GPS system is based on putting a GPS receiver on the ground in a known location, then using it to figure out exactly what errors satellite data contains. The receiver then transmits an error correction to other GPS receivers in the local area and they use that error message to correct their position solutions.

The side scan sonar, towed at five to 10 meters below the surface behind a survey launch, records anything at that depth by taking a electronic photograph of the bottom. A regular depth sounder or bottom sounder gives a general idea of the depth of the bottom. A side scan also surveys not only the bottom, but the area all around the scanner.

Using GPS and the side scan sonar, the crew of the Rainier will also measure movement of the Fire Island shoal, northwest of Fire Island and the Knik Arm shoal directly off Pt. Woronzof. The highest part of the Fire Island shoal has moved nearly two miles south and east since the early 1940s.

Both shoals have the capacity to hinder navigation, but relocating the shipping route around Fire Island Shoal has lessened its influence, corps officials said.

Corps studies show two major freight companies supplying Anchorage, Totem Ocean Trailer Express and Sea-Land Services Inc., each send about 100 ships annually up Cook Inlet. Each company presently incurs about 400 hours of delay, for a total cost of approximately $2 million annually.

"This is the most sophisticated measuring boat on earth," said Gary Daily, port director for the proposed Port MacKenzie, across Upper Cook Inlet from the Port of Anchorage. "When these guys come to town, they will give you a clean bill of health or they won't. This is one government agency that brings brutal reality to marine transportation. Without it you can't attract major transporters, particularly foreign commerce," he said.

The proposed Port MacKenzie site has a natural depth of 60 feet, compared with 35 feet at mean lower low water, at the Port of Anchorage, "but without the NOAA study we can't convince foreign shippers to come here, nor should we be able to" Daily said.

Two Japanese firms have expresed interest in shipping coal from the Wishbone Hill mine down Cook Inlet, using Panamax sized carriers; the largest vessels that can pass through the Panama Canal.

Alaska Journal of Commerce
August 3, 1992

Mat-Su officials want north railbelt coalition

By Margaret Bauman
Alaska Journal of Commerce

Matanuska-Susitna Borough officials are proposing a North Railbelt Coalition to undertake transportation projects needed to make area natural resources competitive on the world market.

"If the borough is ever going to progress and provide proper services for its people, it has to develop something," said Matanuska-Susitna Borough Mayor Ernest W. Brannon, who has meetings planned with officials of the Denali and Fairbanks North Star boroughs.

"We are not providing adequate services now and the schools will take a hit in a year or two because we are getting more population and the welfare population is increasing," Brannon said.

The Mat-Su borough, with about 41,000 residents, currently has 17 percent unemployment and 33 percent of the population is on welfare, the mayor said.

If officials from the Denali and Fairbanks North Star boroughs agree, "we could have it done by year's end," he said. "Fairbanks is fairly pro-development and the Denali Borough has Usibelli Coal Mine and Mat-Su have quite a bit of coal. I can't see any reason why they would not want to."

Brannon, whose borough is pursuing development of proposed Port MacKenzie on Upper Cook Inlet, said Mat-Su also is considering formation of a port authority. "We could go for either one or both," he said. "It might be in our best interests to go for both."

On a short-term basis, Mat-Su borough officials see the coalition providing political muscle.

"A number of significant transportation studies are being completed by the state, the railroad, Alaska Industrial Development and Export Authority and others in late 1992," borough officials said in their proposal. "The North Railbelt Coalition needs some political unity to insure it receives due consideration during the 1993 legislative session."

For the long term, borough officials are looking to erase what they see as artificial municipal boundaries to economic development by coordinating all three boroughs' efforts with a regional perspective.

They also want to pursue public/private joint ventures as a means to build facilities that are efficient, cost-effective and competitive. Participation by the private sector will minimize both public expense and public risk, borough officials said.

They also are looking to form a North Railbelt Regional Port Authority, to pursue port projects and other intermediate transportation links, including road, rail and pipeline projects.

The port authority would be a means to pursue land acquisition, disposition, development and bonding on a coordinated regional basis, borough officials said in their proposal.

Alaska Journal of Commerce August 10, 1992

Inlet shoals migrating

Deep draft navigation could be affected

By Margaret Bauman
Alaska Journal of Commerce

Bathemetry studies of Upper Cook Inlet show most shoals will have moved sufficiently within five to 10 years to affect navigation as we know it, says the captain of the scientific research vessel Rainier.

"There are still navigable channels existing for deep draft traffic to come and go from the Port of Anchorage, but we did find nearly every shoal in northern Cook Inlet is a migrating shoal," said Capt. Thomas Richards, chief officer aboard the National Oceanic and Atmospheric Administration ship.

"Almost every one of the shoals moves except for the Knik Arm shoal," said Richards, whose crew has been remapping the depths of Cook Inlet. "They don't stay where we found them, so we have to stay on top of the situation and monitor them. There are a number of shoals that have the potential to ground a deep draft vessel."

Richards spoke in a telephone interview prior to the departure of the Rainier for Prince William Sound in early August. The waters of northwest Prince William Sound, frequented by numerous cruise ships, are essentially unsurveyed, Richards said.

In conjunction with the NOAA studies in Upper Cook Inlet, scientists from the U.S. Army Corps of Engineers were aboard the Rainier to study extremes and variability in sediment concentrations and bottom characteristics, said Orson P. Smith, a civil engineer in charge of that project.

The shoals in Upper Cook Inlet need to be monitored, he said. "Some of them erode, some of them build. Our understanding is still very rudimentary."

The Fire Island shoal, which NOAA has been monitoring since the 1940s, continues to migrate toward Fire Island, gradually closing off the channel between the shoal and Fire Island, he said.

The Rainier, with a crew of 63, operates in Alaska at a cost of about $15,000 to $20,000 a day, employing a Global Positional System to determine exact locations and side scan sonar to map obstacles potentially hazardous to marine traffic. Richards noted the active role of women crew members in every area of the research ship, including Lt.j.g. Heidi Johnson, in charge of hydrographic data and acquisition system.

The Rainier is the only one of four NOAA ships assigned to the West Coast of the United States in operation because of funding priorities, Richards said. The efforts of U.S. Sen. Ted Stevens, R-Alaska, in pointing out the need for the survey helped clear the way for the Rainier to do the Alaska studies, he said.

The Upper Cook Inlet surveys have been a cooperative effort involving the Port of Anchorage, the corps of engineers, officials from the proposed Port MacKenzie and the U.S. Coast Guard, he said.

There is probably 20-30 years worth of work to survey just in all the passages, bays and inlets in Prince William Sound, according to Richards. "So we work on the highest priority ones first, as best we can, because this is the last survey ship on the west coast of the United States

"We want our charts based on modern survey information," Richards said. "It would be a terrible catastrophe if a ship cruising there were to run aground."

Alaska Journal of Commerce August 10, 1992

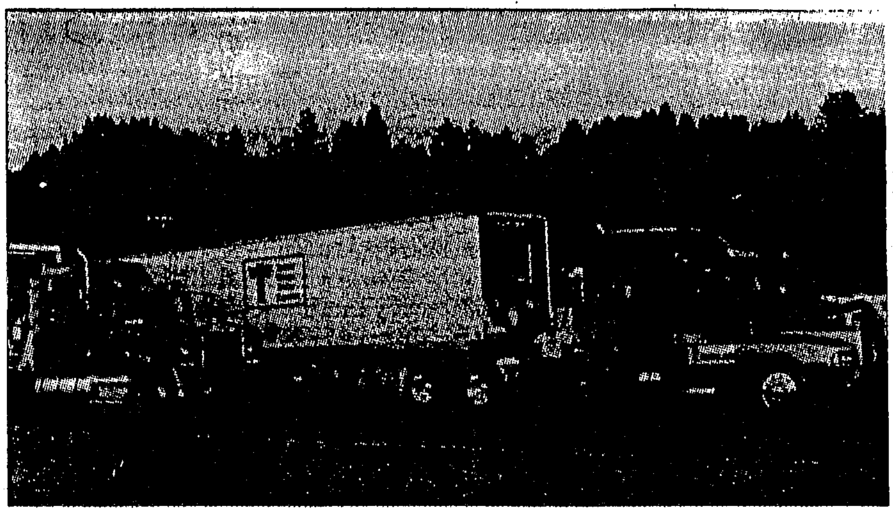

Photo by Margaret Bauman

Jim Weber, left, and Richard Reinke, drivers for Totem Ocean Trailer Express.

TOTE offers own line-haul

By the Alaska Journal of Commerce

Totem Ocean Trailer Express, Inc. has expanded its transportation services with the introduction of line-haul trucking between Anchorage, Fairbanks, Kenai, Homer, Seward and Valdez.

TOTE had previously utilized an independent contractor, Mammoth of Alaska, to perform its line-haul work.

For the new in-house operation, TOTE will employ a nucleus of nine owner/operators who are members of Teamsters Local 959, all previous employes of Mammoth, said Jeff Keck, Alaska general manager for TOTE.

The operation is located in a separate terminal, close to the Port of Anchorage, with 1.5 acres of fenced yard, a small shop for contract maintenance and a 1,000 square-foot administrative office and driver's room.

TOTE currently operates two roll-on/roll-off ships with twice weekly sailings between Tacoma, Wash. and Anchorage.

TOTE recently announced the awarding of a contract to Tampa Shipyards in Florida for the extension of length of TOTE's newest roll-on/roll-off ship, the Northern Lights. The Northern Lights is scheduled to come on line for Alaska trade in the summer of 1993.

Insertion of the 90-foot midship section is scheduled for completion in March. The stretching will make the Northern Lights equal to its two 790-foot sister ships in the TOTE fleet, the Great Land and the Westward Venture, TOTE officials said.

If market conditions warrant, the Northern Lights will be put into service during the peak shipping months of April to October, TOTE officials said.

Founded in 1975, TOTE is a privately-owned Alaska corporation headquartered in Seattle. It is a subsidiary of Totem Resources Corp., which also owns Foss Maritime Co. and Interocean management Corp.

Commentary

Editorial

Let's get to a more logical way of regulating bottomfish

The sooner we move to a freely transferable quota system for offshore bottomfish, the better. What we have now—regulation by season, arbitrary quotas for onshore plants and exclusive fishing zones for shore-based fishing boats—is contrary to sensible economics and will ultimately fail. That will injure this billion-dollar Alaska fishery.

The North Pacific Fisheries Management Council, which regulates federal waters inside the 200-mile fisheries limit (but outside the state's three-mile territorial limit) says it wants to move—eventually—to a "market-based" system for regulating conservation in these fisheries, and a system of transferable quotas seems a good way to go.

But we worry that despite the council's good intentions, institutional and political resistance will build up to protect the current system, which attempts to regulate resource conservation by command and reservation of exclusive rights to inefficient operators.

The demise of Communism demonstrated the bankruptcy of regulation by command. There are several gimmicks in the current regulatory setup: Exclusive fishing areas for shore-based boats, for example, is a way of rewarding for politics' sake inefficient operators (many of which happen to be Alaskan) at the expense of efficient offshore trawlers (most of which happen to be Seattle-based).

Ultimately, this arbitrary system won't work, because if we push the Seattle fleet out, they'll find work elsewhere in an attempt to keep boats and crews fishing. That'll just bring more supply on the market, bringing down prices for everyone.

Case in point: Some Seattle trawlers, having found slim pickings in U.S. waters, are now fishing for halibut and other fish a few miles further west in Russian waters, in joint ventures with the locals. That puts product in the market that competes directly with Alaska fish. Because some of this is landed in Unalaska, it counts as U.S. fish, a point that drives the knife in even deeper.

There should be a better way to do this. Transferable quotas, where fisheries regulators would decide how many fish are to be caught and assign them to boats, Alaska and Seattle-based, that have fished before, seems a way to accomplish this.

Quotas should be salable, so efficient fishermen can buy shares of quota from the less efficient. And newcomers will have a way to get started, by buying into a quota.

The idea has flaws, no doubt, but it's worth investigating. Artificial constraints in economic regulatory systems just don't work. It's better to find ways that let the market function in achieving a goal, which is the biological health and stability of this valuable resource.

Cook Inlet shoals under study

By Orson P. Smith

An outcry of concern from Alaska maritime interests since the late 1980s over hazards of Fire Island and Knik Arm Shoals has led to independent efforts by two federal agencies to improve navigation safety and efficiency in upper Cook Inlet.

The Alaska district U.S. Army Corps of Engineers is authorized to make a one-year reconnaissance study of the feasibility of deep-draft channels in Cook Inlet. And the National Oceanic and Atmospheric Administration responded to public requests for updated charts by scheduling a 1992 hydrographic survey along the approaches to Anchorage.

But coordination meetings of Southcentral Alaska maritime interests beginning in August 1991 decided that the two independent federal efforts would be concurrent. The Corps of Engineers then requested support from NOAA for measurement of conditions related to channel shoaling during the course of the NOAA survey. NOAA agreed, and detailed plans were made by February 1992 for corps technical specialists to share the facilities of the NOAA ship Rainier during its July 1992 survey work near Anchorage.

The Alaska district assembled a team of experts for the work on the Rainier, led by Dr. Orson Smith, the corps' principal investigator of Cook Inlet studies. The corps' Coastal Engineering Research Center in Vicksburg, Miss., provided Dr. Nicholas Kraus, a coastal sediment transport specialist, and Michael Tubman, an oceanographic instrumentation specialist. CERC also provided water sampling devices and instruments to measure water temperature, salinity, and optical turbidity.

The services of RD Instruments of San Diego, Calif. were subcontracted by CERC to provide the use of a modified acoustic Doppler current profiler (ADCP). Atle Lohrmann, Craig Huhta and Blair Brumley were sent to Anchorage by RD Instruments to operate it.

The ADCP consists of a square array of disk-shaped transducers which look from the surface down through the water and outward at a slight angle. Acoustic pulses from these transducers are reflected by particles suspended in the water, and the echoes are sensed by the transducers. The motion of particles relative to the transducers causes the frequency, or pitch, of the reflected sound wave to change, like the rising pitch of an approaching train whistle. This frequency shift, known as the Doppler effect, is sensed by the ADCP and applied to compute the velocity of the water with respect to the ship carrying the ADCP. The ship motion, determined from navigation data, is subtracted from the ship-relative water velocities to reveal the water velocity over the Earth. The navigation capabilities of the Rainier and its survey launches are ideal for this application. A fifth transducer on the modified ADCP looks straight down and focuses purely on the echo amplitude, which is a measure of the amount of sediment in the water.

The NOAA Atlantic Oceanographic and Meteorological Laboratory in Miami provided a special-purpose acoustic device known as an acoustic concentration profiler, which has been used for over a decade to monitor sewage treatment effluent and dredged material discharged in open waters. This device uses a pair of down-looking acoustic beams to sense the concentration of suspended material with high precision. CERC has used both the ADCP and ACP in tandem for dredged material research since 1989. The acoustic conditions in highly turbid plumes of dredged material are similar to natural conditions in upper Cook Inlet. AOML sent Paul Dammann, an ocean engineer, and Jeff Bufkin, an electronics engineer, from Miami to operate the ACP in Cook Inlet.

Work began July 15 with installation of instruments aboard the Rainier's launch RA-5, driven by Coxswain Jackie Buchanan and commanded by Ensign Jonathan Klay. The RA-5 was equipped with satellite navigation and a hydraulic winch for collection of water and bottom sediment samples. Extensive measurements were made during the next 9 days, first in the vicinity of Fire Island Shoal, then Knik Arm Shoal, and finally near the Port of Anchorage and Port MacKenzie. Through each night and through two full days, the acoustic instruments were left running while the RA-5 was tied alongside the Rainier, first at anchor off Fire Island and later off Port MacKenzie. By the evening of July 23, the corps team had collected 61 water samples, 42 surface-to-bottom profiles of water temperature, salinity, and optical turbidity, and over 200 megabytes (200 million digital words) of acoustic data. The team gathered bottom sediments on Knik Arm Shoal to supplement more than 100 bottom samples provided by the Rainier's routine survey operations.

The data from these measurements must undergo extensive post-processing on computers in Anchorage, Vicksburg, Miss., San Diego and Miami, but some conclusions were reached by the team in the course of the data collection. Currents exceeding 5 knots were measured on both the flood and the ebb tides in the vicinity of the shoals. Currents exceeded 4 knots even during moderate tidal ranges. Though the water is consistently turbid, no silt appears to settle on the bottom anywhere near the two shoals. Bottom samples indicate the shoals consist of sand in constant motion along the bottom. The sand appears to originate primarily from the delta of the Susitna and Little Susitna rivers. The Rainier's soundings show a massive southward migration of North Point Shoal, previously north of Knik Arm Shoal. This shoal has merged with Knik Arm Shoal over the last 10 years, closing off the north half of the inlet off Point Woronzof to depths of less than 25 feet at low tide. The crest of Knik Arm Shoal is so hard that it could not be sampled with the device aboard the RA-5, leading the corps team to speculate that large, immobile rocks form this shoal's foundation. The silt that settles in the port area may do so because the concavity of the Anchorage waterfront and of the port excavation itself, allow currents to recirculate and subside enough for fine silt to flocculate and settle to the bottom. The straighter shoreline near the deep natural channel at Port MacKenzie appears to have a stable sandy bottom.

The Rainier's soundings show a massive southward migration of North Point Shoal, previously north of Knik Arm Shoal. This shoal has merged with Knik Arm Shoal over the last 10 years, closing off the north half of the inlet off Point Woronzof to depths of less than 25 feet at low tide.

The corps' November report will combine these observations with full analysis of the data to estimate the cost of dredging a variety of channel geometries, all of which would significantly reduce shipping delays into and out of Knik Arm.

The Rainier has provided the corps with digital soundings from its surveys for use in computing excavation quantities. The technical accuracy of Cook Inlet dredging estimates has been dramatically improved by the contributions of NOAA and the crew of Rainier. Col. John Pierce, the corps' Alaska district engineer, July 24 presented Capt. Tom Richards, commanding officer of the Rainier, with a plaque in recognition of the extraordinary competence and outstanding interagency cooperation provided by NOAA and the Rainier during this summer's operations. The two commanders agreed that the future holds numerous opportunities for further NOAA and corps cooperation in the public service.

Construction Projects

$22 million upgrade of military dorm challenges Aleutian Constructors

The renovation of the U.S. Air Force's main dormitory and center of activity on Shemya Island in the Aleutian Chain has proven challenging for the general contractor in charge of the project. Aleutian Constructors of Anchorage was awarded the $22 million project by the U.S. Army Corps of Engineers. Work on the dormitory and service center began on April 28, 1992. The contract for the renovation of "Building 600," a 232,000-square-foot, 30-year-old structure mandated that renovation was to take place while the building was occupied and with minimal disruption to the lives of the occupants—a challenging prospect for Aleutian Constructors.

The dormitories include quarters for permanent and temporary officer and enlisted personnel and civilian contract employees. The living space upgrades include asbestos abatement, insulation, plumbing and ventilation refurbishment. Support service areas targeted for renovation include the dining, medical, shopping, laundry and post office facilities.

The work is being done in phases determined by areas of the building. As renovation in one area is completed, it is re-occupied and crews move onto to renovate another section of the facility. In addition to the challenges involved in coordinating this part of the project, Leo Walsh, partner in Aleutian Constructors, reports that another challenge has been the "surprises" inherent in the remodel of a building that is 30 years old. In response to these challenges, the U.S. Army Corps of Engineers and Aleutian Constructors have entered into a partnering agreement that is designed to smooth communications and make maximum use of good faith cooperation on all sides.

Aleutian Constructors is a joint venture of Walsh & Company, Inc. of Anchorage and CRK and Associates of Seattle. The firms have been working together on projects for over 20 years.

Contractor reaches half-way point on construction of Shemya 'Ops' building

The new 6000 square foot Operations and Maintenance ("Ops") building being built on Shemya Island in the Aleutians for the US Air Force by Aleutian Constructors is 51 percent complete and on-schedule, according to Leo Walsh, partner in Aleutian Constructors, general contractor for the project. Awarded on Sept. 29, 1991 and started just three weeks later, the project is scheduled for completion in June 1993.

The Ops building includes office and laboratory space, as well as a maintenance area which will service fuel trucks. The $4,701,871 contract, administered by the U.S. Army Corps of Engineers, also includes the construction of a 3,000-square-foot vehicle storage building and fuel dispensing facilities. The storage building will house trucks when not in use, protecting them from Shemya's harsh saltwater environment.

The Ops building is a precast concrete structure, and the vehicle storage building is constructed of metal panels over a structural steel framework. The fuel dispensing facilities include underground storage tanks and related piping. Quality control over this part of the installation, according to Walsh, must be extraordinary to insure against fuel leaks and soil contamination.

Aleutian Constructors is a joint venture between Walsh & Company of Anchorage and CRK and Associates of Seattle. The two firms have been working together for over 20 years.

Construction of Shemya Island communications facility on schedule

The new communications center on Shemya Island in the Aleutians is 48 percent complete, according to Leo Walsh, partner in Aleutian Constructors, general contractor for the project. The 11,150-square-foot building will house communications functions for the U.S. Air Force on Shemya and has areas designated for both equipment operations and maintenance. Features include precast concrete walls and a fully adhered EPDM roof. Awarded in August 1991 by the U.S. Army Corps of Engineers, contract administrators, completion of the project is scheduled for Feb. 11, 1993.

An underground passageway to a nearby building is also included in the $4,924,000 contract. According to Walsh, coordinating construction of this passageway with several existing underground communications cables has proven an interesting challenge for his people.

Aleutian Constructors is a joint venture between Walsh & Company of Anchorage and CRK and Associates of Seattle. The two firms have been working together for over 20 years.

FAA grants $65 million for 43 projects

Grants totaling $64.9 million have been approved by the Federal Aviation Administration for 43 projects in Alaska, FAA officials said. The package includes $5.6 million for reconstructing Postmark Drive at Anchorage International Airport.

Also approved was construction of a new airport at Chenega Bay, for $4.8 million; construction of a runway, apron and taxiway at Nondalton, for $4 million; construction of a new airport at Old Harbor, for $4 million, and new runway realignment at Sand Point, for $4.7 million.

The remaining 38 projects range in size for $112,000 for installation of perimeter fencing at Port Heiden to $3.5 million for apron and taxiway improvements at Ketchikan.

Officials want time to review port study

Mat-Su Borough mayor seeks 40 days

By Margaret Bauman
Alaska Journal of Commerce

Concern over some portions of the South Central Port Study has prompted officials for the Matanuska-Susitna Borough and Port of Anchorage to seek an extension on comments.

"This is a critical study which is going to influence planning for the next 40 years," said Ernest W. Brannon, mayor of the Mat-Su Borough, in a letter Oct. 16 to Commerce Commissioner Paul Fuhs.

"It seems a 40-day extension is not unreasonable."

State officials had initially requested comments by Oct. 23 on the study issued earlier this month. Jim Wiedeman, a development specialist with the state agency, said it would take several major players to delay the comment period and then only for a week or so. "We're trying to get this done," he said. "If it seems a lot of them need more time, we would consider extending it, but we will try to extend it as little as possible."

Brannon noted that the study was already more than 18 months late because of administrative and contract award delays.

> Brannon said he felt the state Department of Transportation and Public Facilities, the Fairbanks North Star Borough and the Denali Borough had been left out of the process and that their comments were critical to the final study report.

Brannon said he felt the state Department of Transportation and Public Facilities, the Fairbanks North Star Borough and the Denali Borough had been left out of the process and that their comments were critical to the final study report.

Brannon also noted that private sector firms in Asia, Canada and the continental United States had significant projects at stake. "I believe a 'reality check' by those firms may make the difference in some investment decisions," he said.

The technical report on development of ports in Southcentral Alaska said Whittier could be the best site for a bulk export port, but planning should begin immediately for Port MacKenzie.

Whittier's location and access to water depth requirements for Capesize vessels make it a prime candidate for a bulk export port, but severe winter snow conditions also need to be carefully considered for impact on bulk handling, the report said.

Authors of the report, prepared by Peratrovich, Nottingham & Drage, Inc., of Anchorage, in association with the McDowell Group, in Juneau, said if Whittier is judged impractical, Seward is the most viable port in the short term, possibly up to 1997, and should remain as a support port for the long term, the report said.

But as coal and timber production increases, Port MacKenzie should be brought on line in the later part of the century, which means planning should start immediately, the report said.

Tyonek also was found to offer the most viable port for West Cook Inlet coal and has transportation and port costs far below other ports, the report said.

Mat-Su Borough officials said they are still on their original course, to build their port in two or three increments, so every increment is self-supporting.

"Mat-Su has not backed off the port," said Borough manager Don Moore. "Quite the opposite." Moore said there had never been a plan to initially build a world-class port, but rather to build to that level in stages which are self-supporting.

"Public attitude is favorable," Moore said. "They would like to see it. They are particularly interested if we open up the jobs in the Interior; not just create a port."

"We were looking for more analytical data reductions ... based upon the real world of market supply, transportation costs," said Roger Graves, governmental and environmental affairs specialist for the Port of Anchorage. It wasn't analytical enough. It may be they were rushed. Maybe that is why we got what we got."

"The question still before us is where can you get the lowest unit cost of transportation," said Bill Blessington, marketing manager for the port. "I have yet to see a single projection on FOB (freight on board) price on a ton of coal in Alaska at any of the existing or proposed port facilities. There also seems to be a kind of difference of opinion on development costs of the proposed ports," he said.

"I am happy with the economic forecast, but not sure the analysis is complete," said Orson Smith, a civil engineer with the U.S. Army Corps of Engineers who organized a port studies group to exchange notes on various studies.

"You need to know what it costs to get the commodity to the market, from the mine to the furnace in the case of coal. That analysis isn't explicit in the draft report."

Smith also said he felt every competing alternative proposed in the study was presented as at least constructable. "They have avoided the very thing they were chartered to do, to make a rational choice between competing alternatives ... a coal port at Seward, a bulk terminal at the Port of Anchorage and Port MacKenzie. It can't be possible to do them all. There is nothing I see in their projections to warrant thee coal terminals," he said.

At the same time, Smith said he was satisfied with information sought from the study regarding shipping paths. That information, plus data from the National Oceanic and Atmospheric Administration studies done in Upper Cook Inlet in July, may allow the corps to recommend further studies for a deep draft channel at the Knik Arm shoal, he said.

"We are going to recommend further study for a deep draft channel ... to deepen Knik Arm Shoal to minus 35 feet deep at low tide or deeper. It is now minus 25 feet at low tide, Smith said.

Anchorage Daily News November 22, 1992

Seward protests Mat-Su's bid for port

By GAIL RANDALL
Daily News reporter

Supporters of an $18 million deep-water port at Point MacKenzie sailed into cross currents Thursday when Seward officials charged the harbor would kill their coal-exporting industry and destroy the maritime town.

"We have all worked very hard to make a bulk shipment port pay for itself without subsidy," Christopher Gates, Seward's port marketing manager, told a joint meeting of the state House and Senate transportation committees. "Now, if we are talking about subsidizing this whole thing ... let's give it to the railroad. Let's give it to the people who have risked their first-born children that they are going to pay back this debt — that have tried for years to make this system work well."

"I don't want to get into Seward bashing," Port MacKenzie marketing specialist Steve Minor said later, "but

Please see Page B-3, PORT

PORT: Seward officials say Mat-Su plan would kill town

Continued from Page B-1

they've cut every corner and they're still not competitive."

For three decades, folks in the Matanuska-Susitna Borough have kicked around the idea of building a port on Point MacKenzie — a knuckle of land roughly two miles across Cook Inlet from Anchorage. They've envisioned ships hauling coal, timber, limestone or other exports. They've dreamed of profits from property taxes, land leases and wharfage fees fattening the borough tills. As state and federal revenues steadily declined in recent years, efforts to build the port intensified.

But Mat-Su voters — also facing tough times — rejected a ballot proposal in 1989 for $25 million in port bonds. A month later, a Boston firm dubbed the proposal "speculative" and predicted the port would lose millions before — and if — it ever turned a profit.

Borough leaders pressed on. They spent $1 million for a road to water's edge and more than $527,000 in the past two years on port development. Recently, the borough assembly voted 6-1 to spend an additional $160,700. All but $30,000 of the money is earmarked for newsletters, slide shows, "public information campaigns," and Port Director Gary Daily's consulting fees.

The $30,000 is to plan a railroad spur from Houston to the point. Dick Knapp, vice president of Alaska Railroad marketing, told the panel of legislators Thursday that the spur could cost $50 million to build. The legislature could be called on to help pay for the spur.

Now, borough officials say the port would "conservatively" net $3.8 million a year in its first five years and $6.5 million a year after that. The figures are based on fees they'd charge shippers, Daily said earlier this week. No shippers have yet committed to using the port, he added.

Supporters say the port is necessary to win important coal contracts from South Korean and Japanese buyers looking to feed their coal-powered utility plants. One potential buyer — Idemitsu Alaska Inc. of Japan — owns lease rights to Wishbone Hill north of Palmer. The company had planned to begin mining last year, but the land is caught up in the Mental Health Lands Trust litigation between the state and mental health advocates. Hundreds of acres throughout the state are in limbo until the issue is resolved.

When that happens, Mat-Su hopes to begin hauling coal to Point MacKenzie for Idemitsu.

Thursday, Daily told the legislators that British Columbia, Australia and Indonesia "are eating our lunch," because they can supply coal much cheaper than Alaska. Although Alaska has large coal deposits, the cost of hauling from the Interior to Seward's port eats into profits and discourages buyers, he said.

Knapp said in a later interview that the railroad no longer makes any money off the runs to Seward because of concessions. That makes the short haul to Point MacKenzie appealing, but the railroad is in no position to pay for the $50 million spur, he said.

Daily told legislators that coal shipped by train from the Interior to Seward is so expensive that Seward's port operator — Korean-owned Suneel Alaska Corp. — is considering jumping ship for Port MacKenzie if the port is built.

"Coal that is not now competitive would be competitive" if shipped from Port MacKenzie, Daily quoted a Suneel representative as saying.

But Dale White, Seward city councilman and Suneel operations manager, countered that the ice-free port in his city is "highly underutilized" and could make money if given more business. The port now ships 700,000 tons of coal each year, and could handle several million tons, he said.

Gates, Seward's port manager, pleaded with legislators not to encourage what he sees as a duplicate port that would pit two communities against each other for the same exports.

"I believe — if the numbers aren't cooked," he said, referring to a legislature-sponsored feasibility study due out next April, "you will see that there is no justification for an additional Southcentral port."

FOCUS

Corps of Engineers would dredge Knik Arm shoal

By Margaret Bauman
Alaska Journal of Commerce

A new U.S. Army Corps of Engineers study on the feasibility of dredging the Knik Arm shoal in Upper Cook Inlet indicates current and proposed marine traffic would be greatly enhanced by dredging.

Preliminary estimates for initial dredging of the channel to widen it to 1,000 feet at minus 39 feet at mean low low water are that it would cost $2.28 million, said Orson Smith, a civil engineer with the U.S. Army Corps of Engineers Alaska District.

Corps estimates are that some 353,000 cubic yards would have to be excavated initially, followed by 80,000 cubic yards of material in the second and fourth years following the initial dredging. The maintenance dredging would run about $433,600 each time, the corps estimated.

"It's a whole lot lower than we anticipated when we started the study," said Smith, in a presentation Dec. 4 before the Cook Inlet Port Studies coordination group at the Port of Anchorage.

Officials with the proposed Port MacKenzie in the Matanuska-Susitna Borough talked with Smith Dec. 5 at Palmer and concluded they would support the dredging effort.

"It would enhance access to the Port of Anchorage or Port Mackenzie," said Gary Daily, port director for Port MacKenzie. "All of us agreed it was a priority." Smith also was scheduled to meet with Port of Anchorage officials to discuss the dredging prospects further.

Using computer models, the corps produced ship transit simulation results which showed dredging the shoal would result in average time savings ranging from 2.5 hours to 140.5 hours for individual ships moving to and from the Port of Anchorage.

Ships coming into the port have to adjust speed enroute to Cook Inlet so their arrival on Knik Shoal coincides with high water. For the average Sealand Services ship making the run, dredging the shoal could knock an average of 3.8 hours off the outbound trip, the study showed. For ships owned by Totem Ocean Trailer Express, the computer model showed average delays of 5.9 hours reduced to 2.8 hours through dredging. For Panamax coal carriers, not presently a factor in Cook Inlet traffic, projected average delay time without dredging was computed at 144.5 hours, compared with 4.1 hours with dredging, the corps report showed.

For hypothetical outbound Panamax coal carriers, fully laden at 42 foot draft, delays of up to 144.5 hours could be encountered under some tides without the dredging the shoal. With dredging, the average delay time would be about 4.1 hours, the corps study showed.

Options open for the dredging include one involving congressional authorization and a cost-sharing agreement involving local governments, with earliest dredging to begin in the summer of 1998.

The local sponsors' share of the $1.4 million feasibility study to precede dredging would be $739,000, the corps preliminary figures showed. The other option, for a small project authority, calls for dredging to begin in the summer of 1996. The catch to the latter is the federal government would fund no maintenance dredging once $5 million was spent. Smith estimated that would cut off federal funding after the year 2000.

Orson Smith PHOTO BY M. BAUMAN

Smith said the corps has already been appropriated some funds which could be used for the project, but they can't be touched until the cost-sharing agreement is signed. He favors the congressional authorization plan, for which the complete Washington-level review conceivably would be completed by August 1997.

"We have to do a lot more detailed study," Smith said. "The most sensitive factor is our prediction for maintenance dredging... a very difficult prediction," he said.

APPENDIX B

ENGINEERING

APPENDIX B
ENGINEERING

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FIGURES

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FIGURES--Continued

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TABLES

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March 25, 1993

APPENDIX B
ENGINEERING

1. UPPER COOK INLET CONDITIONS

1.1 Introduction

The physical setting of Cook Inlet is reviewed in section 2 of the Main Report. This appendix provides some additional detail, with a focus on conditions which directly relate to design of navigation improvements. Several figures from the Main Report are repeated in this appendix for the sake of continuity.

1.2 Bathymetry

Figure B-1 (see also figure 2-9, Main Report) shows the general bathymetry of Cook Inlet. Large expanses of water deeper than 200 feet (ft) are prevalent in lower Cook Inlet south of the East and West Forelands. The depth of the inlet from the forelands north to the confluence of Turnagain Arm and Knik Arm (west of Fire Island) is generally greater than 60 ft. Detailed soundings indicate an average 90-ft depth at low tide along the shipping route in this region. Broad sandy shoals control the depths along shipping routes past Fire Island to Anchorage on Knik Arm (see figure B-2 and figure 3-1, Main Report).

1.2.1 Fire Island Shoal. Fire Island Shoal offers the first major constraint to Anchorage-bound deep draft vessels, extending across Knik Arm from Fire Island to deltaic shoals of the Little Susitna River (figure B-2). West Point Shoal is an elongated feature extending southwestward from West Point on Fire Island, lying south of Fire Island Shoal. The Point MacKenzie visual range is designed to guide ships between the crest of Fire Island Shoal and West Point Shoal. The evolution of Fire Island Shoal was investigated by the Corps of Engineers in 1986 (see summary in subsection 4.1.1, Main Report). The crest of the shoal has migrated southward since about 1941, causing pilots in recent years to cross northward instead of southward of the crest. The 1992 controlling depth along the northern flank of the shoal is about 48 ft at mean lower low water (MLLW). The U.S. Coast Guard is in the process of changing the system of navigation aids in the area to accommodate the northern route past Fire Island Shoal.

1.2.2 Knik Arm Shoal. The shallowest shoal along the present shipping route to Anchorage is Knik Arm Shoal. This feature is a dome-shaped mound centered between North Point on Fire Island to the southwest, Point Woronzof to the east, and Point MacKenzie to the northeast (figure B-2). The shoal is flanked to the north by North Point Shoal, a broad sandy shoal associated with the delta of the Little Susitna River. Woronzof Shoal lies to the south, an elongated sandy shoal extending southwestward from Point Woronzof. Knik Arm Shoal is marked in ice-free months by U.S. Coast

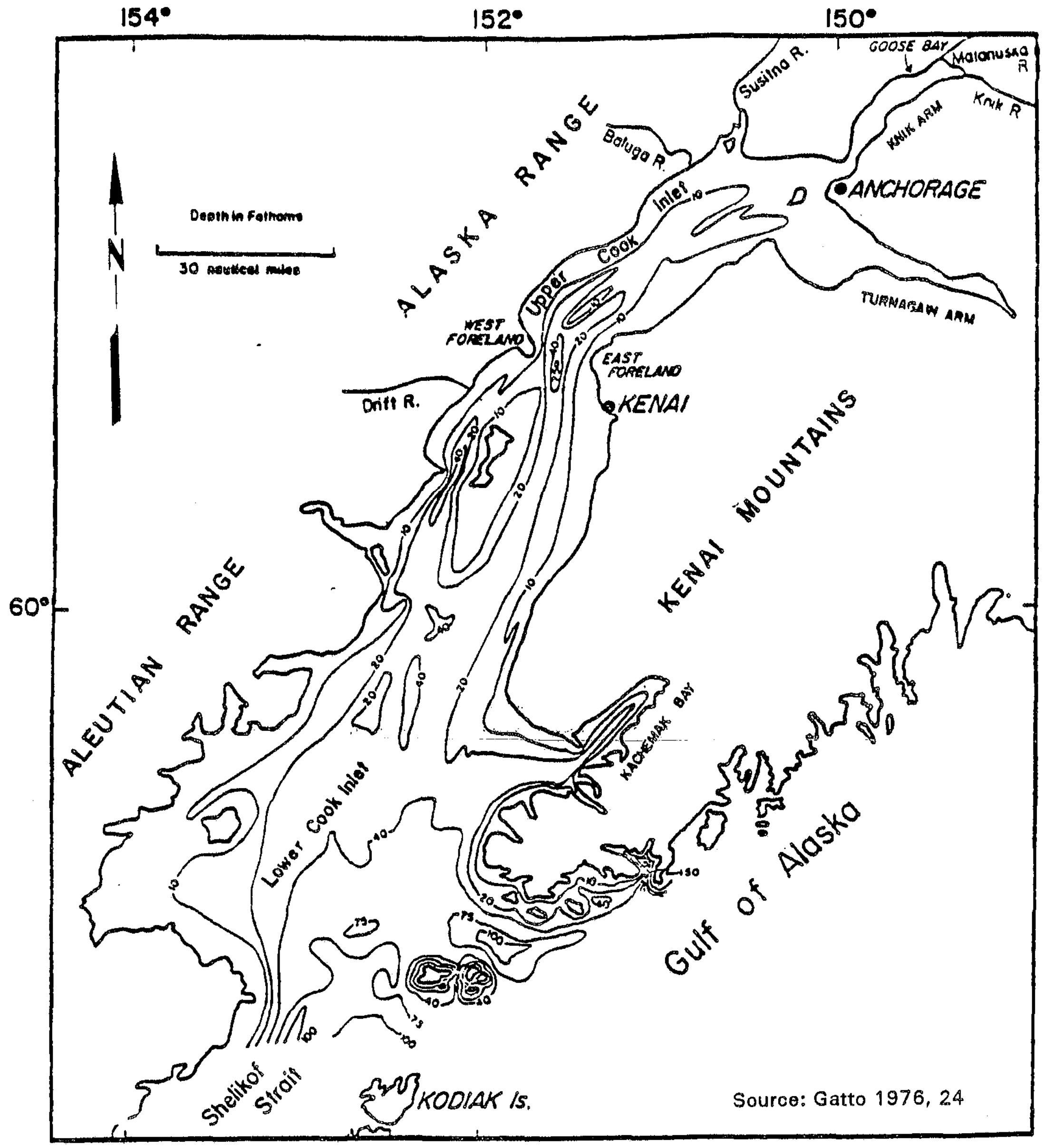

FIGURE B-1.--Generalized bathymetry of Cook Inlet, Alaska.

Guard buoys which guide vessel pilots across the north flank of the shoal on approach along the Point MacKenzie visual range. The buoys guide pilots across the southern flank of the shoal on departure along the Fire Island visual range.

Previous hydrographic change analyses (USACE Alaska District 1978 and 1988) indicate that major shifts of North Point Shoal and Woronzof Shoal have happened in the past on a time scale of 5 to 10 years, at times reaching Knik Arm Shoal at the -30-ft-MLLW level. Preliminary data from the 1992 National Oceanic and Atmospheric Administration (NOAA) survey of the area (figure B-3) indicates that North Point Shoal since 1982 has extended itself southward nearly to the Point MacKenzie Range west of Knik Arm Shoal. The controlling depth along the Point MacKenzie Range is now about 25 ft at MLLW over a reach of approximately 5,000 ft. This is a dramatic change from conditions

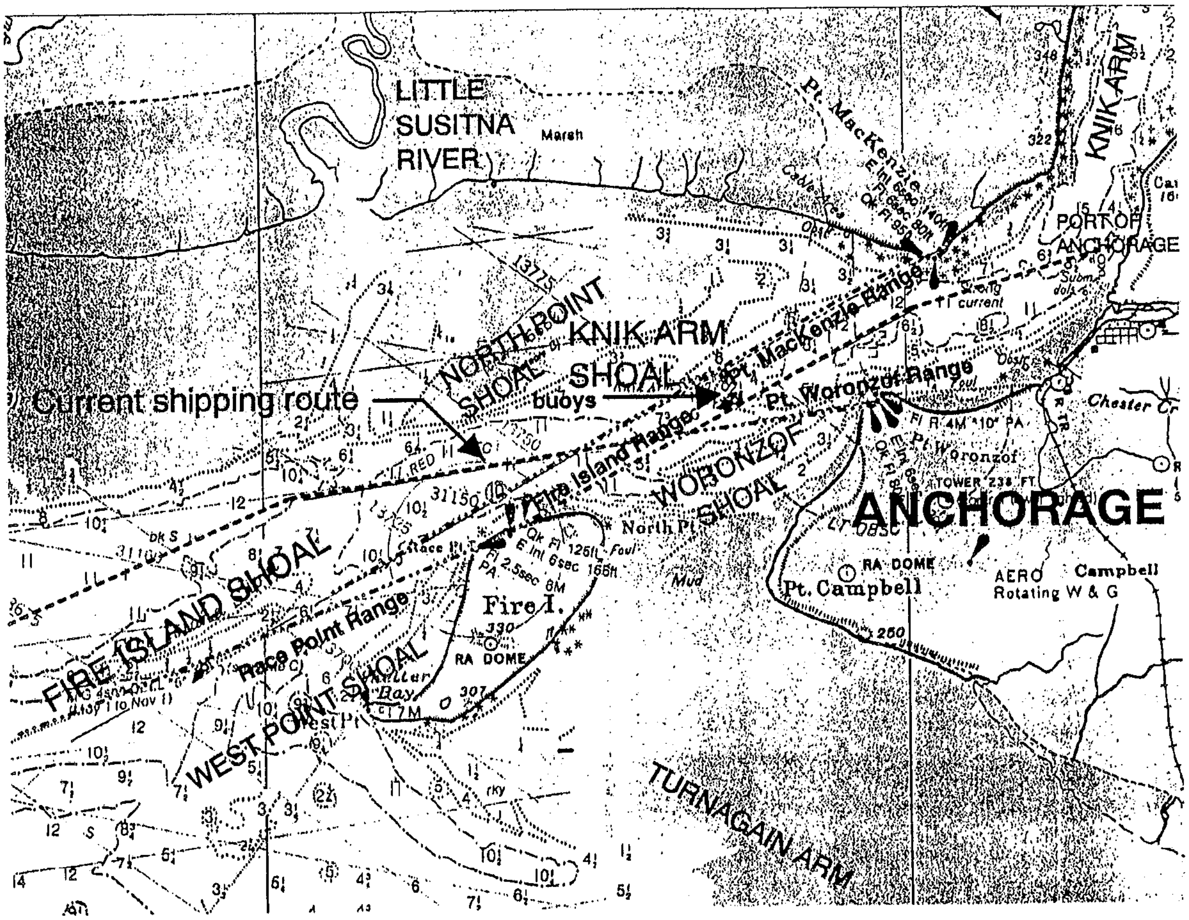

FIGURE B-2.--Excerpt from nautical chart 16665 (NOAA 1990) with names of key features and navigation aids in upper Cook Inlet.

plotted on the published nautical chart 16665 (NOAA 1990), which are based on 1982 NOAA soundings. The controlling depth along the southern passage is also about 25 ft at MLLW, but the shallowest points near the Fire Island range are more in the form of pinnacles, as indicated by figure B-4.

A recording fathometer was operated continuously during Corps of Engineers measurements aboard the NOAA ship *Rainier* in Knik Arm during July 1992. Inspection of fathograms indicates bottom undulations of short wavelength that are almost certainly dunes generated by the bed-load transport of sand. The wavelength is difficult to measure from the time scale of the fathograms. The height of the dunes is more precisely measured, at times exceeding 1 meter (m), which is consistent with the observations of Bartsch-Winkler (1982). Side-scan sonar records aboard the *Rainier* indicate bed-forms of this scale are common in Knik Arm.

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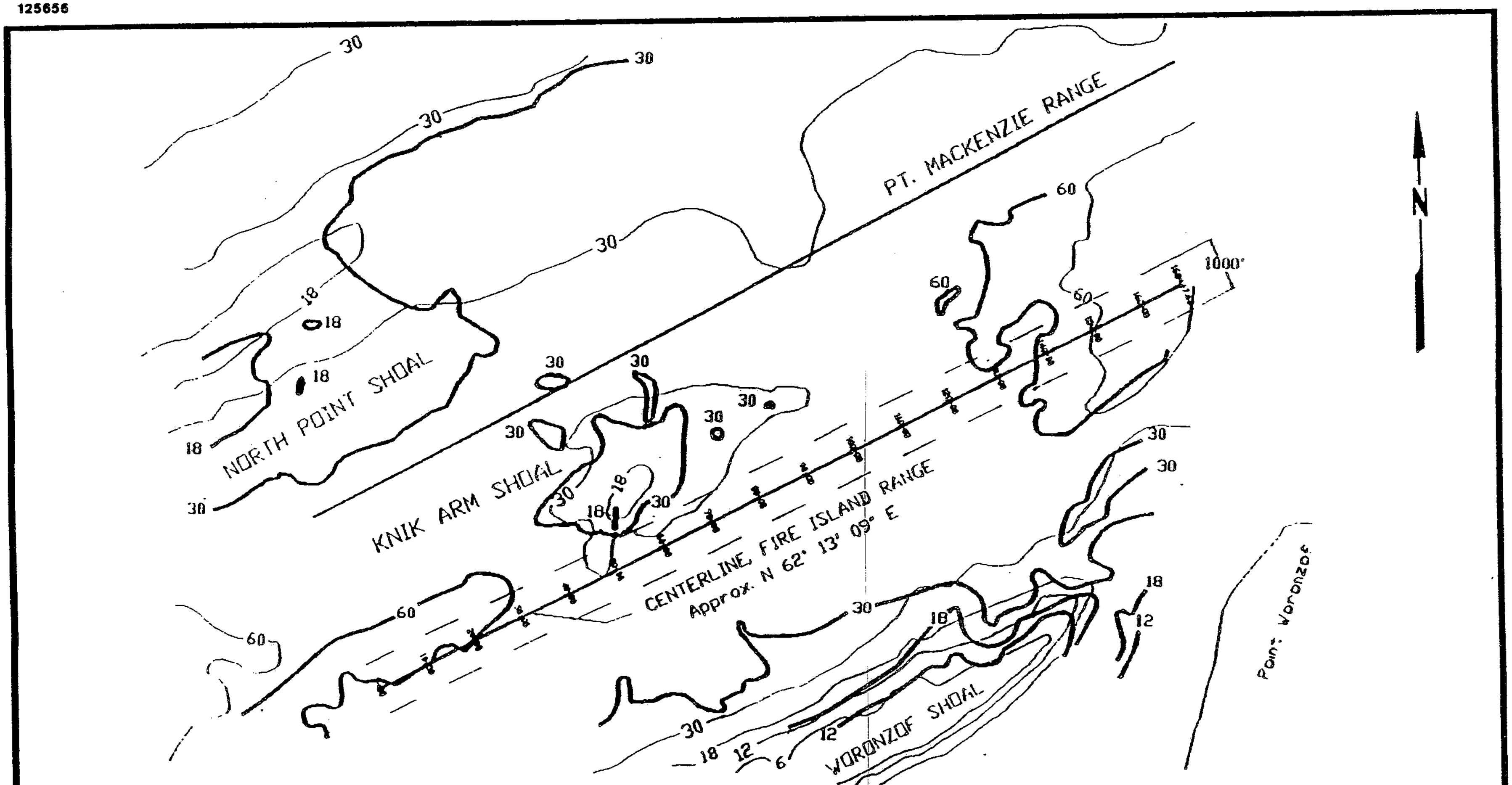


1982-1992 CONTOURS

30 - NOAA Chart 16665 (1982 Soundings)

30 - 1992 NOAA SURVEY DATA

2000 0 1000 2000 3000

APPROXIMATE SCALE (FT.)

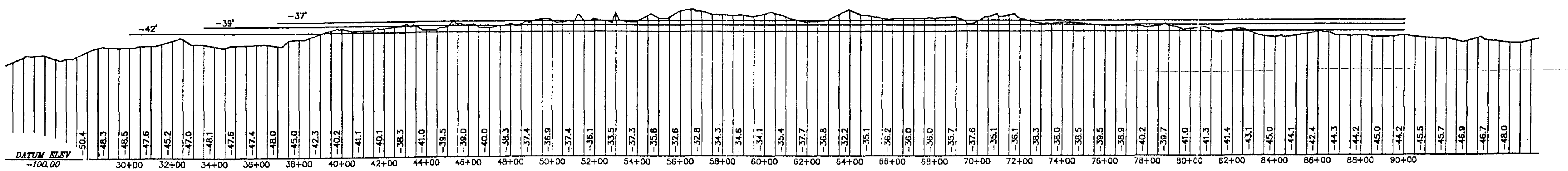
UPPER COOK INLET CONTOURS, 1982-1992

US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

B-3

125656



Source: NOAA soundings 1992 (preliminary)

PROFILE ALONG FIRE ISLAND RANGE

US Army Corps of Engineers
Alaska District

COOK INLET

NAVIGATION

B-4

A one-time emergency dredging project was accomplished in 1975 along the Fire Island Range. The Corps of Engineers hopper dredge *Biddle* removed 1.1 million cubic yards by special Congressional authority to support the construction of the Trans-Alaska Oil Pipeline. Unfortunately, no detailed surveys were accomplished in conjunction with the 1975 dredging, due to time and budget constraints. The *Biddle*'s operational goal was to provide a controlling depth of 35 ft at MLLW along the Fire Island Range. NOAA soundings in 1976 indicate -25-ft-MLLW soundings in the vicinity of the dredging project, but the records are unclear as to whether this was a product of active shoaling or beyond the limits of the dredging. Evidence from 1992 bottom samples of hard material at high points on Knik Arm Shoal indicates that present controlling depths are not the product of recent shoaling. The high points on Knik Arm Shoal, especially along the southern half, appear to be essentially unchanged, or perhaps slightly eroded, from 1982 soundings (figure B-3). The *Biddle* may have achieved a controlling depth of only 25 ft at MLLW in its 1975 excavations, since controlling depths appear to be stable hard points in an area that is otherwise subject to natural scour.

1.3 Geotechnical Conditions

1.3.1 Basement Rocks. The basic shape of the Cook Inlet basin, as defined by the Alaska Range to the west and the Chugach and Kenai Mountains to the east, has had its present form since the early to middle Pleistocene Epoch, or roughly 1 to 2 million years. Igneous and metamorphic rocks, primarily of Mesozoic age (138 million to 240 million years), are exposed in the mountains surrounding Cook Inlet. These rocks form the basement complex of the region and are overlain by petroleum and coal-bearing sedimentary rocks of the Tertiary Period (5 million to 63 million years old), which are exposed in the foothills and extend across the basin (see also Main Report, subsection 2.1.3). In the lower elevations, Tertiary rocks are overlain by deposits of the Quaternary Period (the last 2 million years). Data from well logs and other evidence indicate that bedrock lies from 700 to 1,000 feet below the surface of the Knik Arm area.

1.3.2 Effects of Glaciation. The Pleistocene Epoch (10,000 to 2 million years ago) of the Quaternary Period is noted for its glaciations. The Cook Inlet region appears to have been extensively glaciated. The Naptowne glaciation, which began its retreat about 15,000 years ago, was the last of these ice periods (Karlstrom, 1964). Northern Cook Inlet was filled from the Kenai Peninsula to the Alaska Range at the peak advance of the Naptowne and previous Knik glaciations. Prior glaciations entirely filled the Cook Inlet basin. The present topography and bathymetry of the Cook Inlet region and the distribution of sediments across the region are primarily the products of glacial scouring and deposition.

Two aspects of glaciation which cause geological features of interest are glacial lakes and moraines. Glacial lakes still exist in Alaska, formed by ice dams across mountainous drainage basins. Ice-age glacial lakes were very large, and some may have existed for thousands of years. The Naptowne and Knik glaciations both closed off the lower end of Cook Inlet, each time creating a vast glacial lake. Finely ground sediments, mixed with coarser material, have accumulated in layers tens of feet thick across much of the Cook Inlet region. This material consists of blue-gray silt, gray laminated silt and sand, and stratified sand and gravel. The streams which fed glacial lakes formed deltas at the lake margins which can be detected in the distribution of deposited material. Glacial lake levels in the Cook Inlet region may have been as high as the present-day 1,000-ft elevation. Final drainage of major glacial lakes in the region appears to have been complete by about 9,000 years ago.

Terminal moraines are deposits of soil and rocks that accumulate at the leading edge of a glacier. During advances, moraines are literally plowed into a heap by the ice. Many of the prominences along Cook Inlet are associated with moraines. The East and West Forelands, for example, probably mark the maximum advance of the northern portion of the Naptowne glaciation. Moraines are eroded by flowing water during recession of glaciers, and the eroded sediments are distributed in patterns typical of streamflow. The patterns of moraines and glaciofluvial deposits are confused in the vicinity of the confluence of Knik Arm and Turnagain Arm, including the Anchorage area, since this region was the site of confluence of two glaciers. Intermediate glacial advances and retreats during the Naptowne period may have exposed and covered this area several times.

1.3.3 Marine Deposits. The period between the Knik and Naptowne glaciations was marked by an ancestral Cook Inlet with sea levels which reached approximately 50 ft higher than present levels. Radiometric dating of organic materials by Reger and Updike (1983) indicates an interglacial period lasted from about 52,000 to 47,000 years ago. Investigators have found conflicting evidence regarding the details of the sequence of glacial retreat, glacial lake drainage, and advance of the interglacial sea. Blue-gray clay deposits associated with sedimentation in the interglacial sea, known as "Bootlegger Cove" clay, lie beneath much of Knik Arm and the Anchorage area.

Investigations of the feasibility of a causeway across Knik Arm in the late 1970's and early 1980's generated new information concerning local marine geotechnical conditions. The focus of most efforts was north of the Port of Anchorage. Winterhalder, Singh, and Bruggers (1984) summarized an extensive literature review and findings of several prior field investigations associated with Knik Arm Crossing studies. They concluded that subsurface conditions were complex and had yet to be fully defined, but generally confirmed the regional characterizations of Karlstrom (1964) and later refinements of Reger and Updike (1983). The bottom of Knik Arm, from Anchorage to north of Cairn Point, was found to blanketed with recent deposits of loose, highly liquefiable sand and silt. These surface sediments are underlain by sands and gravels of glacial origin (*i.e.*, of the Naptowne glaciation). Below the glaciofluvial deposits lies a thick deposit of soft to very stiff clay, the Bootlegger Cove formation. A few samples revealed a very dense granular material below the clay, probably deposited by the Knik glaciation. These investigators concluded that recent surface deposits and Bootlegger Cove clay are poor foundation for any sort of bridge or causeway, but that glaciofluvial deposits could in places provide sufficient support.

Bakus *et al.* (1979) investigated bottom conditions and circulation in the vicinity of Point Woronzof in relation to discharges from the Point Woronzof Sewage Treatment Facility. Tidal flats in this area were found to consist of fine silts and clays in upper levels and sand and pebbles at lower levels. Offshore sediment samples revealed sand, pebbles, and cobbles. Hard materials hampered offshore sampling. Organic content was 2.3 to 5.5 percent of the fine material and 0.8 to 2.3 percent of the sands.

Bartsch-Winkler (1982) studied the characteristics of sediments and bedforms on tidal flats of upper Knik Arm. She found asymmetric megaripples of sand and gravel at the lowest levels exposed. The surface of the lower tidal flats was generally composed of - saturated, well-sorted, and highly liquefiable sand, with minor occurrences of gravel. Occasional boulders were encountered at the surface of the tidal flats; they had been transported there while frozen to pans of ice. These "ice rafted" boulders eventually run aground, and ice melt prevents reflotation. Dunes found on the lower tidal flats ranged from 0.5 to 1.2 meters (m) in height and from 3.1 to 6.2 m in wave length. Smaller bedforms occurred all across the tidal flats. Most bedforms appeared to be oriented so as to propagate in the direction of the maximum tidal currents. This investigation concluded that surface sediments in the lower tidal flats were in motion with each tidal cycle.

1.3.4 Seismic Activity and Effects of the 1964 Earthquake. Tectonic movement accompanied by earthquakes and tsunamis has played an important role in the detailed form of Cook Inlet, as noted in subsection 2.1.3 of the Main Report. Most of Cook Inlet is classified as seismic risk zone 4, susceptible to earthquakes with a magnitude of 6.0 to 8.0 with major structural damage. The risk of tsunamis from the Gulf of Alaska is limited by diffraction and shoaling at the entrance to Cook Inlet, but seismic water waves generated inside Cook Inlet are a serious threat. The constriction of the forelands and the shallow water beyond reduce the tsunami risk in upper Cook Inlet. The 1964 earthquake generated tsunamis that were disastrous on Kodiak Island, at Seward, and in Prince William Sound. Tsunamis caused less damage in Homer, Seldovia, Halibut Cove, and other areas of Cook Inlet, but may still have reached a height of 24 feet in Kachemak Bay. Most of Cook Inlet subsided because of the earthquake, but the western shore from Kamishak Bay to West Foreland was uplifted. All of Knik Arm and Turnagain Arm subsided in 1964 (Wilson and Torum 1968).

1.3.5 Knik Arm Shoal. The National Oceanic and Atmospheric Association (NOAA) ship *Rainier* collected 120 samples of bottom material as a routine increment of the ship's 1992 hydrographic survey mission. After visual classification for chart notation, the samples were provided to the Corps for lab testing. A subset of the NOAA samples was selected for testing, including 46 samples from Point Woronzof west to North Point on Fire Island. The distribution of these samples is noted on figure B-5. Ten supplemental bottom samples, using the *Rainier*'s grab sampler, were collected by the Corps of Engineers at Knik Arm Shoal (see figure B-6). Seven attempts at collecting a sample on the shallowest point of Knik Arm shoal were unsuccessful, presumably because of a very hard bottom. Figures B-5 and B-6 indicate each sample location with a dot, beside which is noted the sample number, median grain size (D_{50}, mm), and engineering classification code, as defined in the figure legend. Examples of test results for these samples are presented in the supplement to this appendix. Contours of D_{50} are plotted on figures B-5 and B-6, which identify a center of coarse material at Knik Arm Shoal. Surrounding bottom surface materials are sand, with silt content generally increasing at the tidelands. An average grain size for bottom materials on and surrounding Knik Arm Shoal is 0.43 millimeters (mm) (medium sand). Data concerning the coarsest fraction indicates Point Woronzof as a separate concentration of coarse material. This trend will probably be more evident when NOAA samples east of Point Woronzof are tested.

Knik Arm Shoal is known from previous Corps of Engineers studies to have a foundation of very hard material, probably a glacial deposit of consolidated gravel, cobbles, and boulders. The dredge *Biddle* encountered large quantities of rounded pea gravel in 1975 and occasionally recovered large cobbles. A sizable boulder was brought to the surface by a clam-shell dredge that was brought to the site for a one-day exploration prior to the *Biddle*'s arrival in Alaska. The sum of geotechnical knowledge indicates that Knik Arm Shoal is probably part of a glacial moraine. The shallowest points are apparently coarse, stable material, which once removed probably would not return.

1.4 Oceanography

1.4.1 Overview. The Main Report (subsection 2.1.5) provides a review of general oceanographic conditions. The following paragraphs provide additional details on upper Cook Inlet, with emphasis on conditions affecting the evolution of Knik Arm Shoal and the design of an excavated channel at this site. Cook Inlet is noted as a macro-tidal estuary with tidal ranges ranking second highest in North America and among the highest in the world. Diurnal tidal ranges increase from around 16 ft near the entrance to 28.8 ft at Anchorage. All Cook Inlet tides are marked by a substantial diurnal inequality. Tidal currents are strong and dominate in upper Cook Inlet over wind, riverine, or Coriolis-induced circulation. Tidal currents in lower Cook Inlet are affected by the Coriolis force, and a cyclonic (counter-clockwise) circulation is superimposed on the semidiurnal rotation of tidal flows. This causes tidal ranges and salinities along the Kenai Peninsula (eastern) shore to be higher than those of the western shore. Fresher water along the western shore of lower Cook Inlet tends to have more winter ice. Water properties change gradually from a stratified influx of the Gulf of Alaska water in lower Cook Inlet to well-mixed brackish water in upper Cook Inlet. Wave conditions in lower Cook Inlet are also typical of open ocean conditions, though Gulf of Alaska swell is diffracted by the islands across the entrance to Cook Inlet. Waves in upper Cook Inlet are both fetch- and depth- limited, but still hazardous during storms. Strong tidal currents opposing wind-generated waves are particularly dangerous for small craft.

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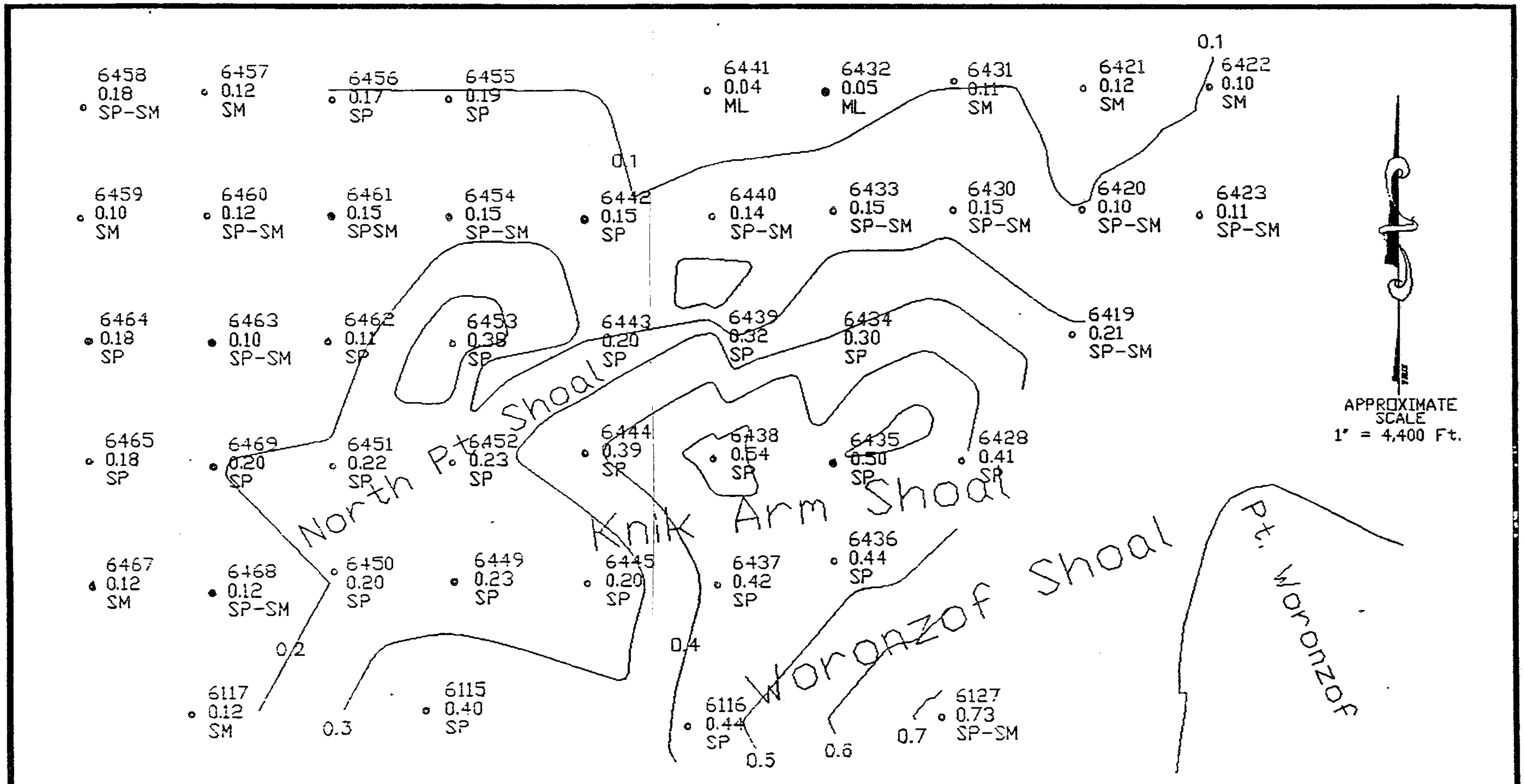

LEGEND
6467 = sample size
0.12 = median grain size
SM = classification code

Classification codes include:
GP = poorly graded gravel with sand
ML = sandy silt
SM = silty sand
SP = poorly graded sand
SP-SM = poorly graded sand with silt

NOAA BOTTOM SEDIMENT SAMPLES, 1992

US Army Corps of Engineers
Alaska District

COOK INLET
NAVIGATION

B-5

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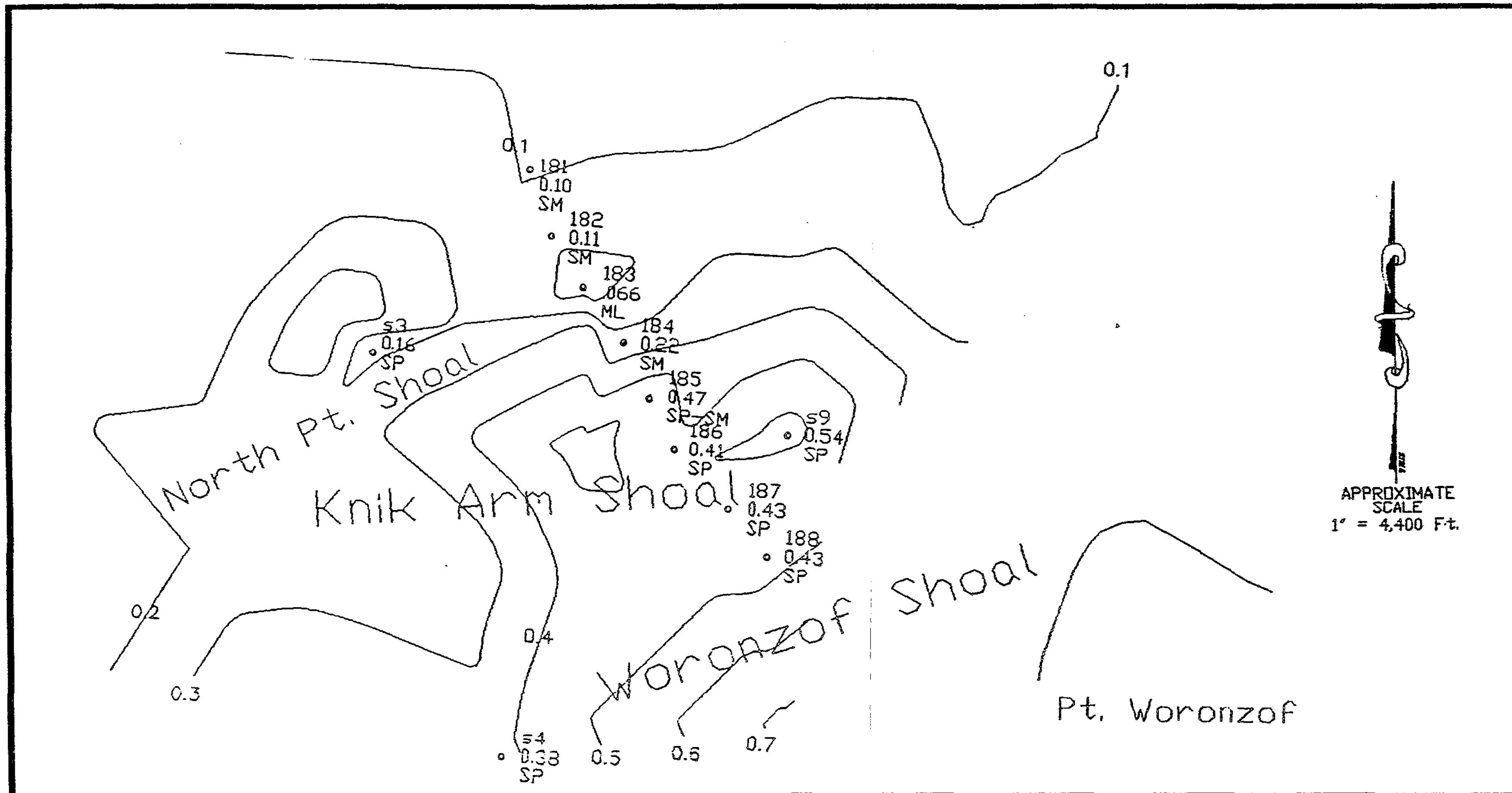

LEGEND 6467 = sample size
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CORPS OF ENGINEERS BOTTOM SEDIMENT SAMPLES, 1992

US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

B-6

1.4.2 Knik Arm Currents. Circulation in Knik Arm was reviewed by Gatto (1976), who also noted trends from satellite imagery. Variations in turbidity revealed that ebb flows tend to move out of Knik Arm north of Fire Island and stay concentrated on the north side of the upper Cook Inlet. Few indications of significant cross-channel flow were apparent in most of Knik Arm, except at times near low tide when bottom friction causes small-scale eddies. A larger flood tide anti-cyclonic (clockwise) gyre was confirmed from earlier studies in the crescent-shaped bay from east of Point Woronzof north to Cairn Point (see figure B-2). This gyre is presumed to be responsible in part for the siltation that is greater along this shore than at other places in Knik Arm. Images of 1973 conditions indicate a tendency for scour west of Point MacKenzie during early flood. Erosion was dramatic in this area between 1982 and 1992 (see figure B-3).

NOAA accomplished a thorough program of field measurements and circulation analyses from 1973 to 1975 (NOAA 1981) all across northern Cook Inlet, including Turnagain Arm and Knik Arm. Water levels, currents, and water properties were measured at stations in Knik Arm indicated in figure B-7. Tidal currents between Fire Island and Eagle River (well north of Cairn Point) generally did not exceed 3 knots, but reached maximums over 4 knots southwest of Point MacKenzie and opposite the Port of Anchorage.

Bakus *et al.* (1979) monitored the motion of metallic drogues and styrofoam drift cards in 1977 to study circulation in the vicinity of Point Woronzof. Drogue velocities were measured as high as 4.5 knots. Drogues released off Point Woronzof tended to move up and down the center of Knik Arm and did not follow any nearshore eddies or larger gyres. Drift card velocities reached 3.4 knots and followed patterns similar to the drogues. Attempts to delineate circulation patterns with surface dye releases were unsuccessful due to rapid dispersion in the highly turbid water.

The U. S. Army Coastal Engineering Research Center applied the Digital Automated Radar Tracking System (DARTS) to measure surface currents in upper Cook Inlet during a period of spring tides in July 1986 (unpublished data, Coastal Engineering Research Center, 1986). Radar-reflecting drogues were deployed in Knik Arm from the Port of Anchorage to Fire Island and tracked by DARTS. Maximum surface currents to 7.8 knots occurred on flood tide opposite the Port of Anchorage. Maximum ebb surface currents to 7.3 knots were measured between Point Woronzof and Point MacKenzie. Drogue movements suggested the presence of a gyre east of Point Woronzof during flood currents and at the Port of Anchorage during ebb currents. These currents are considerably faster than any measured by more direct means, and an error in scale is suspected. The circulation trends are consistent with previous findings. A numerical model of circulation was developed in conjunction with the DARTS measurements and verified in part by 1975 NOAA data. Funding limitations at the time prevented the model's use for thorough exploration of circulation trends. The modeling work could, however, be recovered and adapted to expedite future modeling efforts in the feasibility phase.

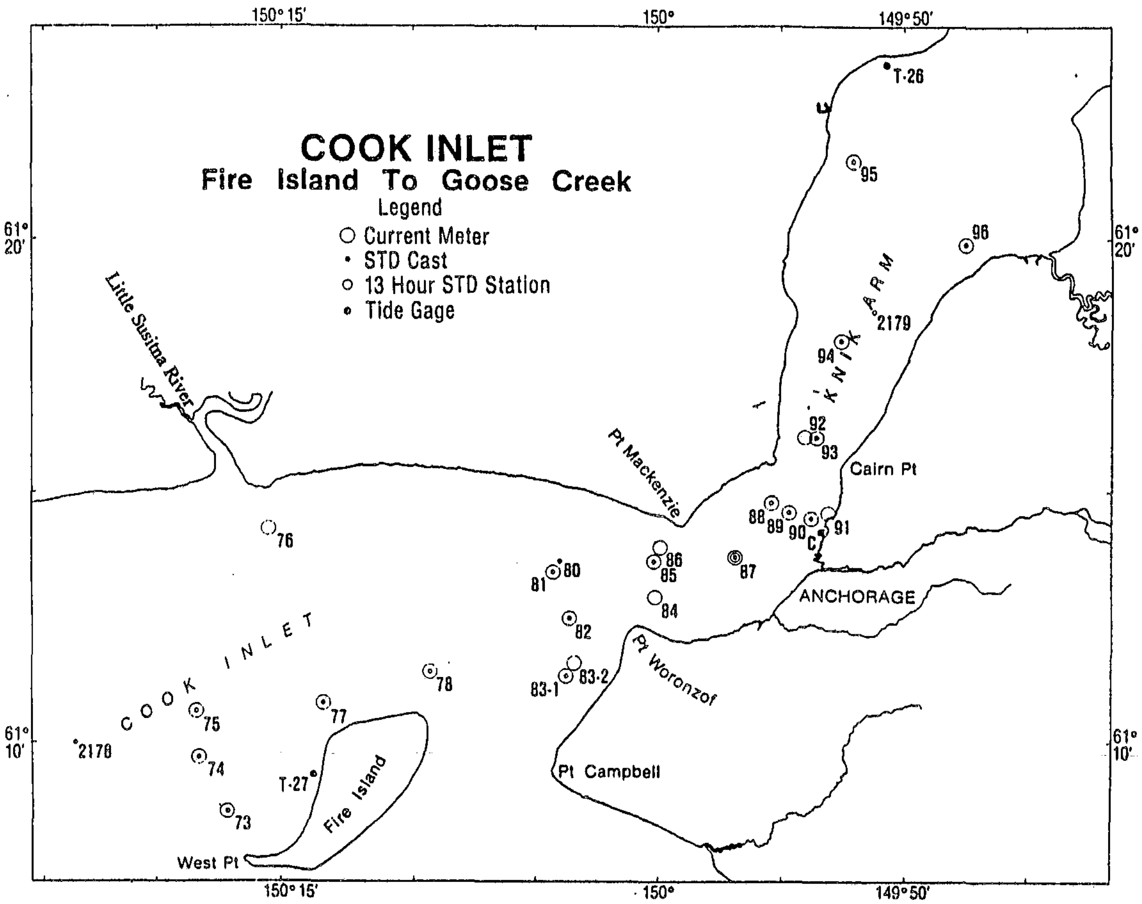

FIGURE B-7.--Sites of NOAA measurements, 1973-75.

Currents were measured in July 1992 by the Corps of Engineers with an acoustic doppler current profiler (ADCP). The instrument was deployed outboard on a launch from the NOAA ship *Rainier* and configured to resolve 1-m layers over a depth range of 25 m (Lohrmann and Brumley 1992). The instrument was deployed with the launch in motion along predetermined courses, as indicated in figure B-8. Courses were repeated to measure both flood and ebb currents. Launch speeds between 6 to 7 knots allowed 10-m horizontal resolution along these courses. Measurements were also made at anchor during full tidal cycles at two different locations, one north of Fire Island and the other west of Cairn Point. Doppler shifts in the frequency of echoes were reduced to measurements of currents relative to the vessel. Vessel navigation data in turn allowed reduction of data to currents relative to the earth with directional accuracy of 1° - 2° and current speed accuracy of about 0.1 knot.

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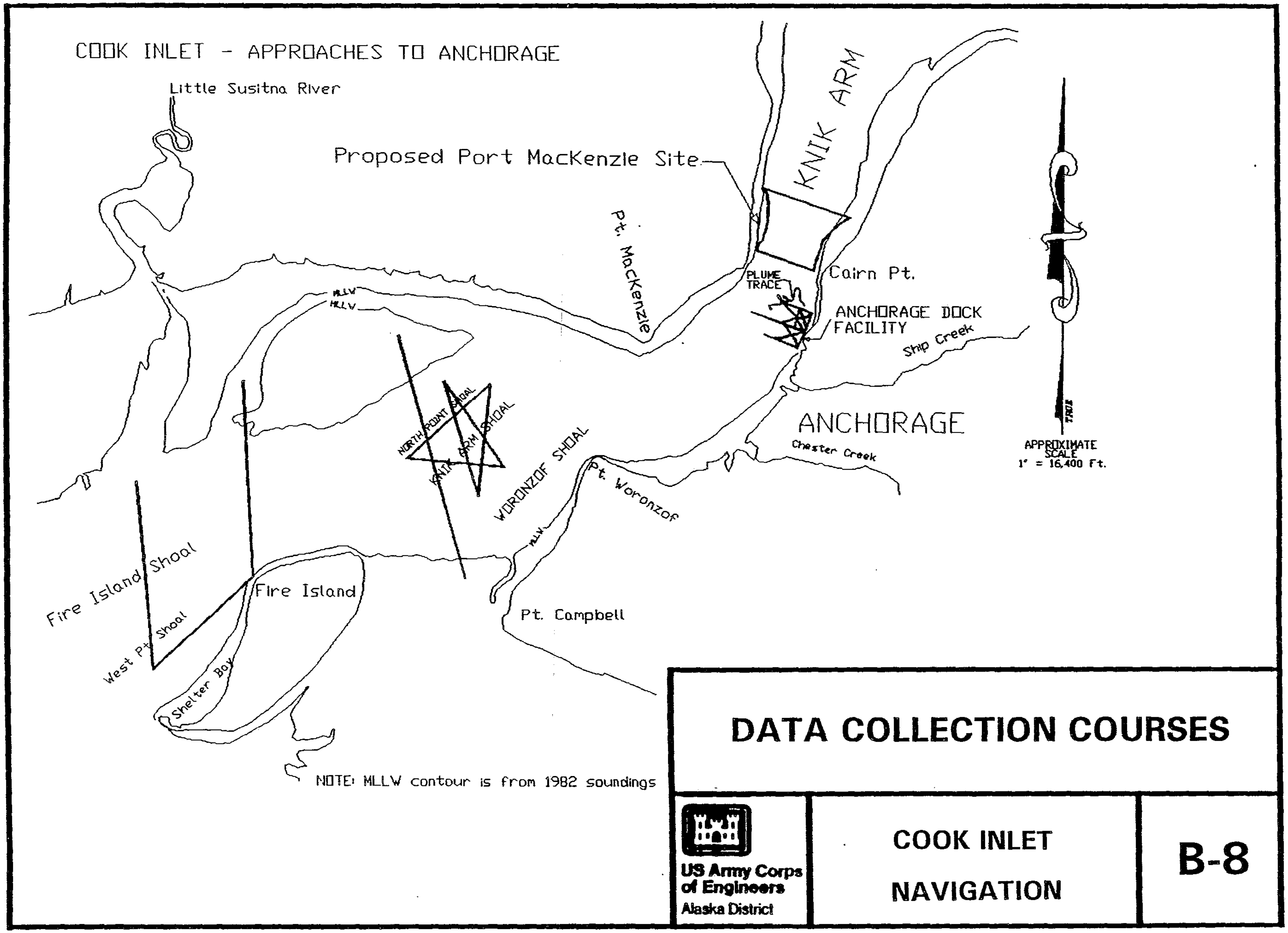

COOK INLET - APPROACHES TO ANCHORAGE
Little Susitna River
Proposed Port MacKenzie Site
KNIK ARM
Pt. MacKenzie
Cairn Pt.
PLUME TRACE
ANCHORAGE DOCK FACILITY
Ship Creek
ANCHORAGE
Chester Creek
APPROXIMATE SCALE 1" = 16,400 Ft.
TRUE
MLLV
MLLV
NORTH POINT SHOAL
KNIK ARM SHOAL
WORONZOF SHOAL
Pt. Woronzof
MLLV
Fire Island Shoal
Fire Island
West Pt. Shoal
Shelter Bay
Pt. Campbell
NOTE: MLLW contour is from 1982 soundings
DATA COLLECTION COURSES
US Army Corps of Engineers
Alaska District
COOK INLET
NAVIGATION
B-8

Current data were plotted as vertically averaged vectors, as shown across from Race Point on Fire Island in figures B-9 and B-10, across Knik Arm Shoal in figures B-11 and B-12, across from the Port of Anchorage in figure B-13, and across Knik Arm north of Cairn Point in figures B-14 and B-15. Currents normal to the vessel course were also displayed as consecutive gray-scaled profiles, roughly equivalent to a transect contour plot. These images appeared with great clarity in real-time on a high-resolution color monitor, but unfortunately do not reproduce well in black and white. Examples of transect current plots are shown in figures B-16 (same course as figure B-10), B-17 (same as first leg of figure B-11), and B-18 (same course as figure B-13). The gaps in figures B-13 and B-18 are due to depths beyond the range of the instrument when bottom-tracking pulses could not be used for precise vessel positioning.

Time and funding limitations in this reconnaissance phase allowed very little of the 160 megabytes of 1992 current data to be reviewed or applied toward circulation analysis, but some trends are discernible from the field data. Vertically averaged currents at mid-tide (see figures B-9 to B-15) generally ranged from 3 to 3.5 knots in deeper water, but tidal ranges were in a neap tide (minimum range) cycle during the field measurements. Spring tides might increase vertically averaged currents by 10 to 20 percent. Maximum currents tend to occur in the deepest areas near the surface (see figures B-16 to B-18). Currents measured near the bottom rarely exceeded 1 knot. Currents appear to be reversing with little rotation or indication of cross currents. More detailed analysis, particularly of the "star" pattern across Knik Arm Shoal and the "sawtooth" pattern at the Port of Anchorage (see figure B-8), may reveal large-scale circulation trends.

Small-scale hydraulic phenomena caused by bottom friction were observed in abundance. Indications of strong localized upwelling, with a boiling appearance, or downwelling, with a slick appearance and convergence of flotsam, were common along the flanks of shoals. These effects tend to occur where steeper banks are significantly diverting strong horizontal tidal currents. Stronger vertical currents and cross-currents were measured in these places, indicating secondary flow in the form of a roll cell, similar to the circulation at the bend of a river. The places where currents are accelerating tend to experience surface divergence, upwelling currents, and scour, while areas of deceleration tend to experience surface convergence, downwelling currents, and deposition. The magnitude of these secondary currents appears to be less than 1 knot, but still sufficient to keep sediment in suspension or even to resuspend bottom material. Though most sediment transport may occur as relatively uniform bed load, areas of stronger vertical currents are key action zones for evolution of the larger shoal features in Knik Arm. The relatively small scale of these phenomena and their three-dimensional nature render them a difficult feature to simulate explicitly with a comprehensive numerical model. An implicit method of predicting the redistribution of bottom materials associated with these hydraulic phenomena will have to be developed in future simulations of shoal evolution.

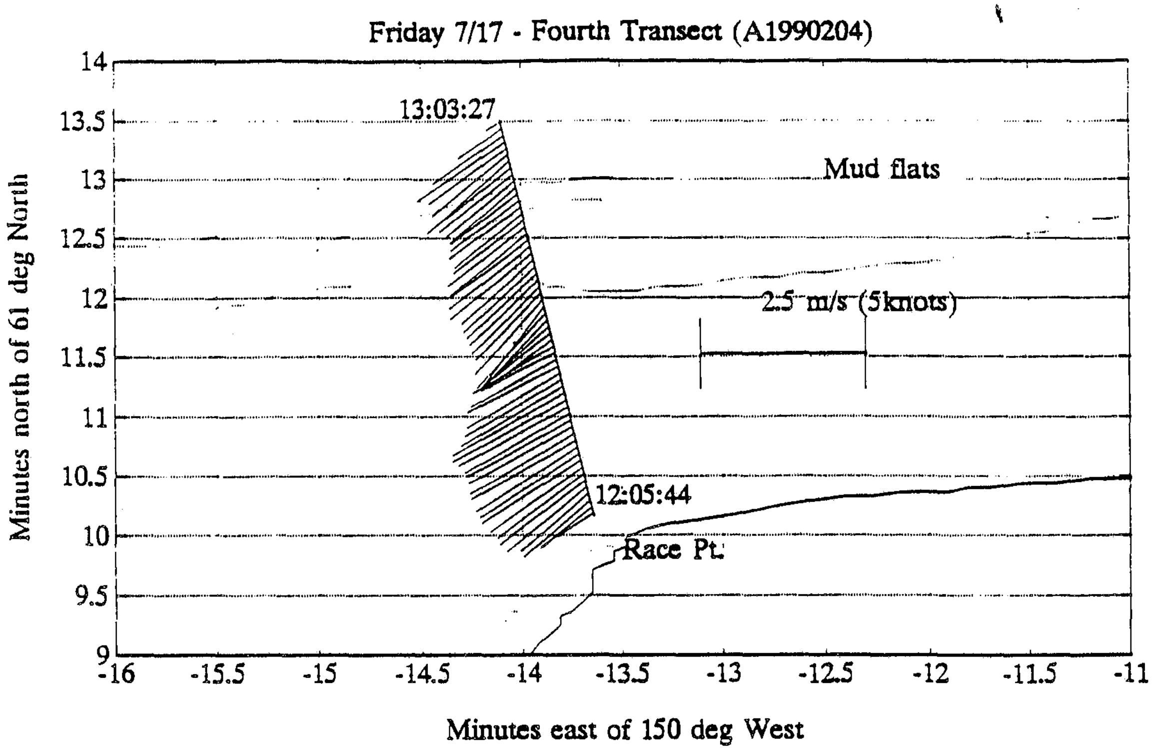

FIGURE B-9.--Vertically averaged current vectors on an ebb tide across Knik Arm from Race Point on Fire Island, July 17, 1992.

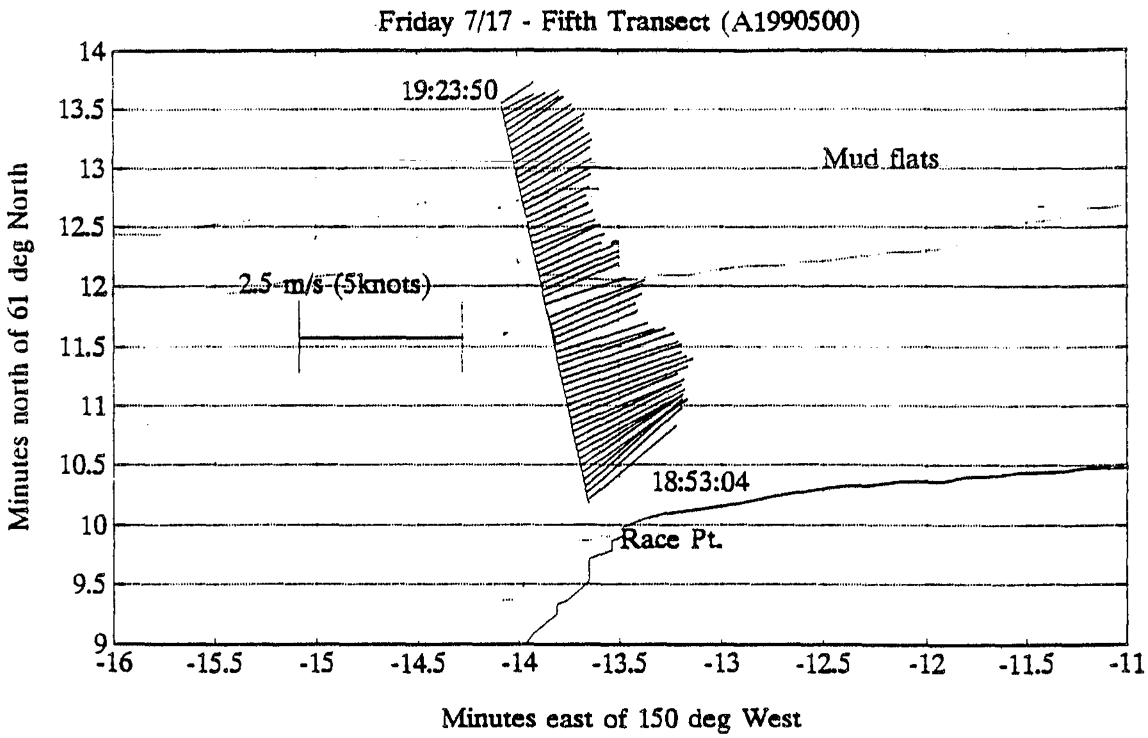

FIGURE B-10.--Vertically averaged current vectors on a flood tide across Knik Arm from Race Point on Fire Island, July 17, 1992.

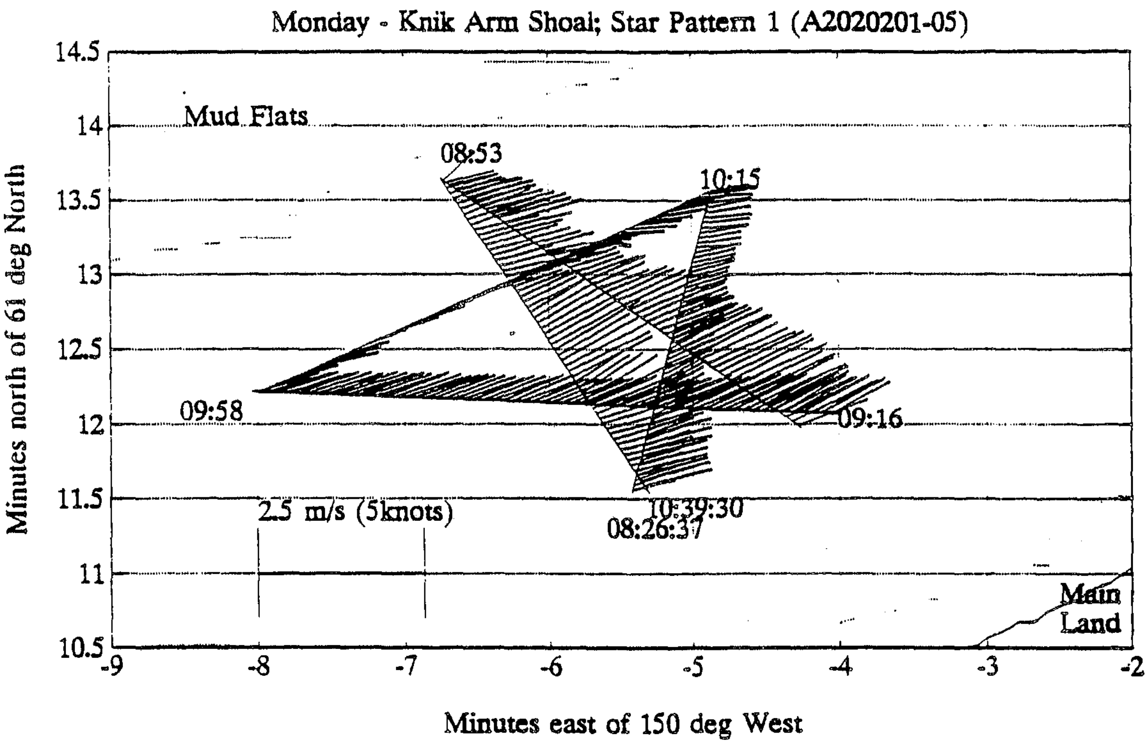

FIGURE B-11.--Vertically averaged current vectors across Knik Arm Shoal on a flood tide, July 20, 1992.

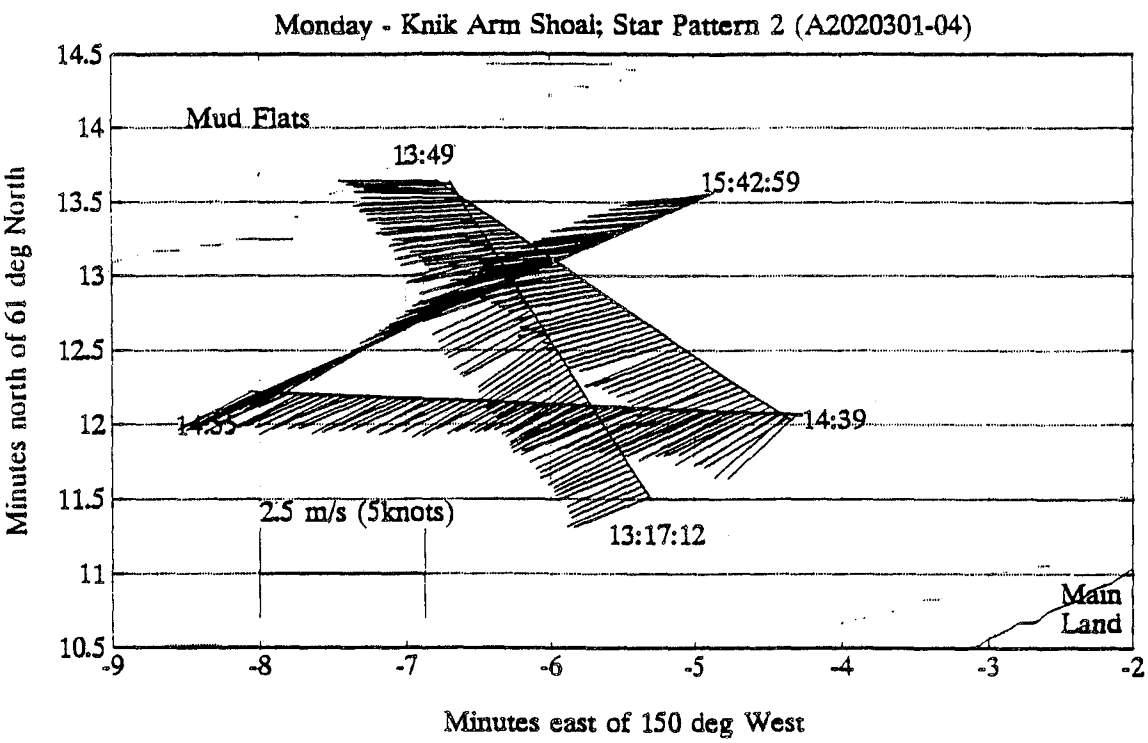

FIGURE B-12.--Vertically averaged current vectors across Knik Arm Shoal on an ebb tide, July 20, 1992.

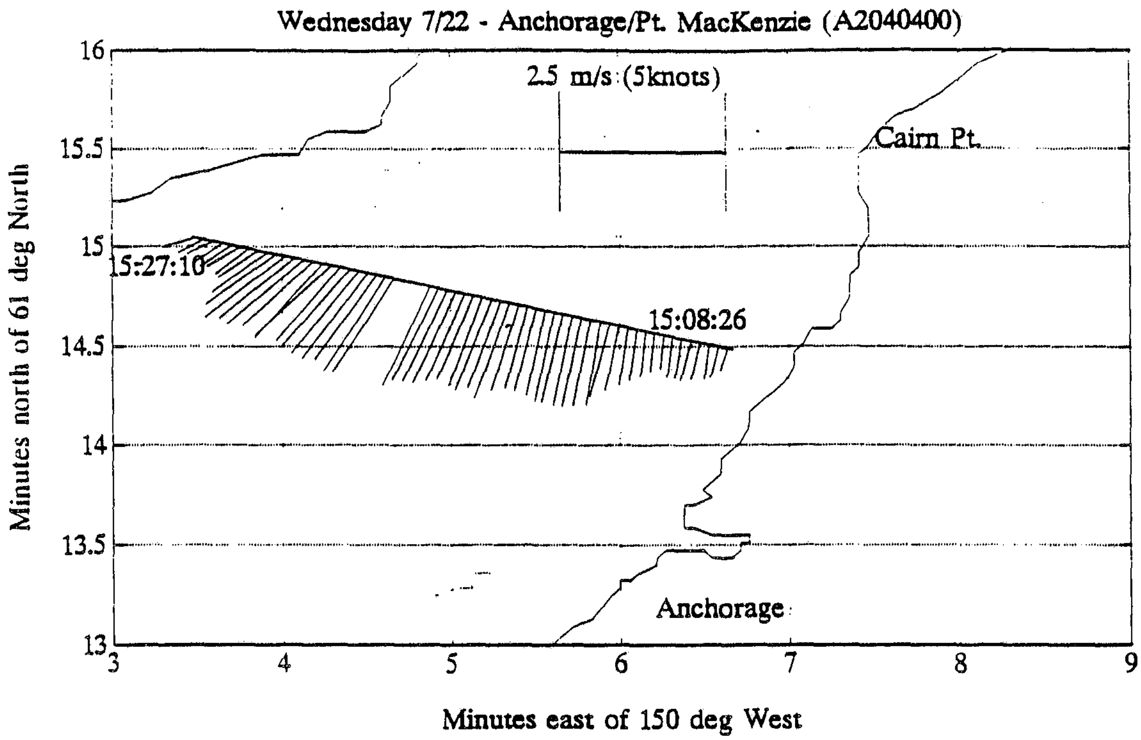

FIGURE B-13.--Vertically averaged current vectors across Knik Arm from the Port of Anchorage on an ebb tide, July 22, 1992.

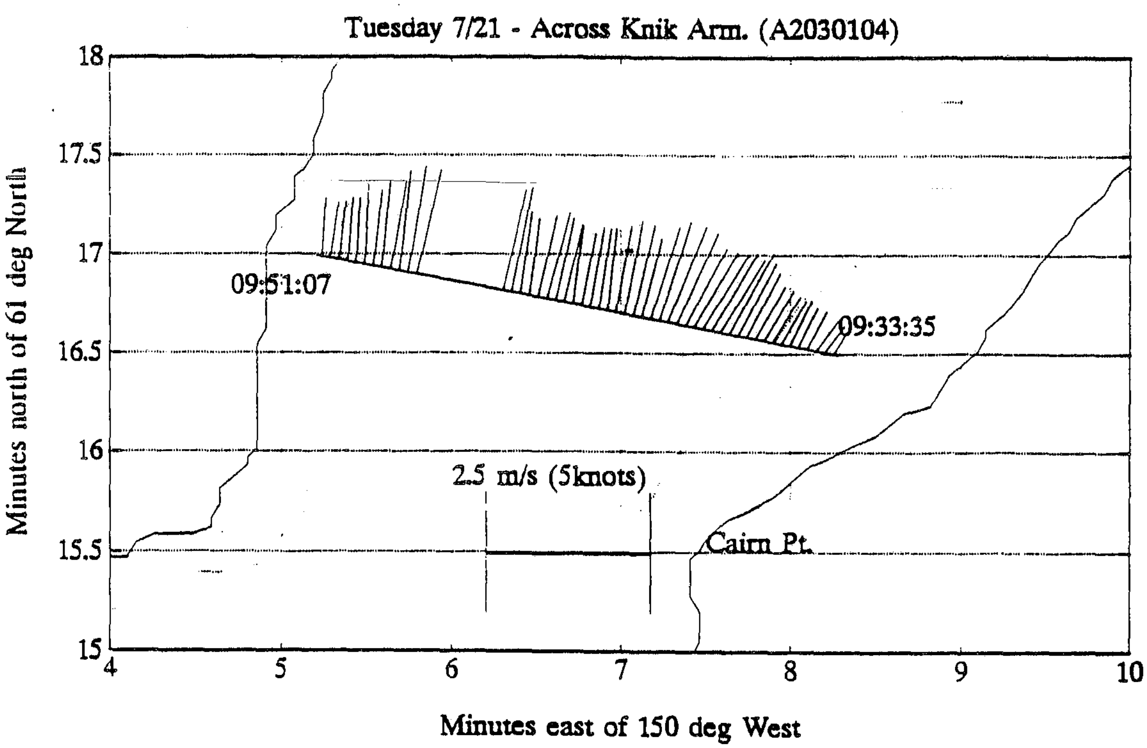

FIGURE B-14.--Vertically averaged current vectors across Knik Arm north of Cairn Point, generally opposite the proposed site of Port MacKenzie, on a flood tide, July 21, 1992.

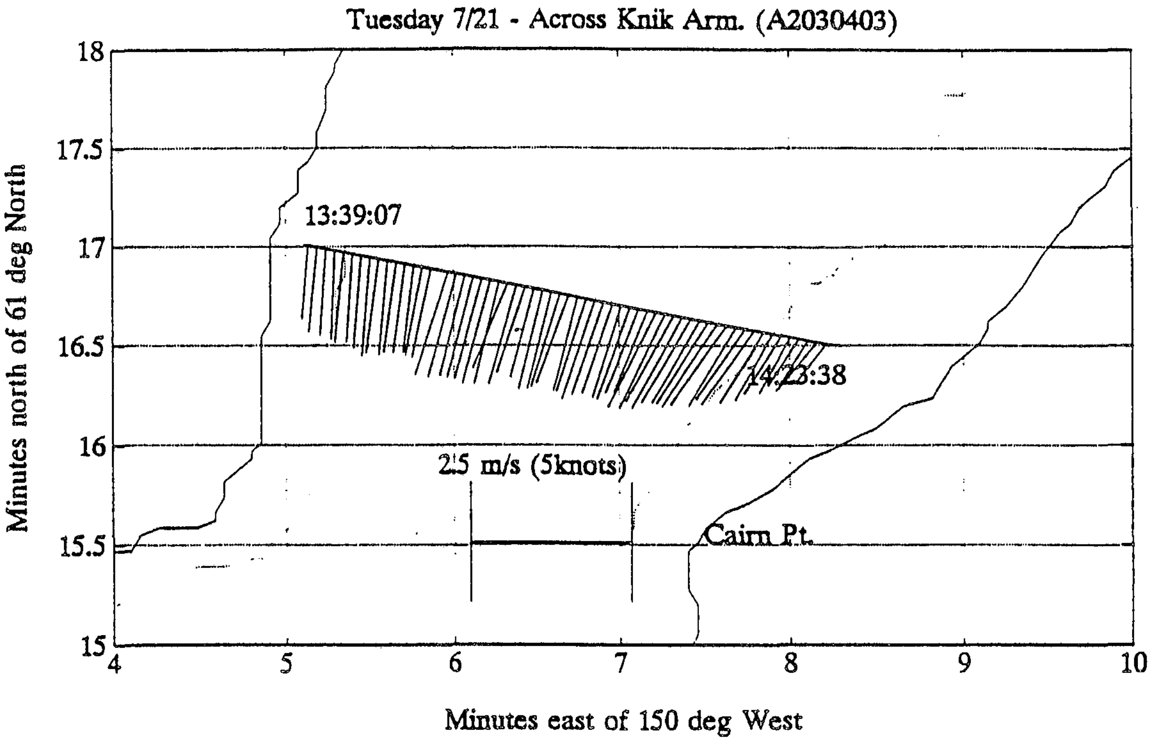

FIGURE B-15.--Vertically averaged current vectors across Knik Arm north of Cairn Point, generally opposite the proposed site of Port MacKenzie, on an ebb tide, July 21, 1992.

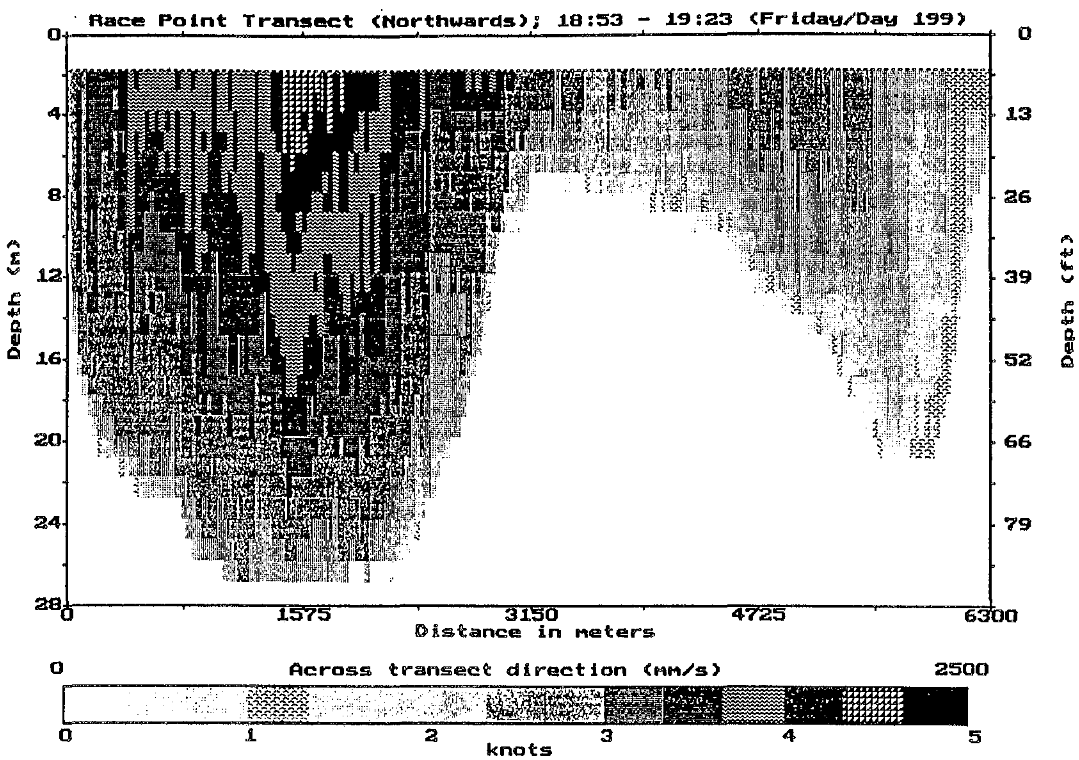

FIGURE B-16.--Consecutive vertical profiles of current speed off Race Point on Fire Island, normal to the course of figure B-10, across Knik Arm from Race Point on Fire Island on a flood tide, July 17, 1992.

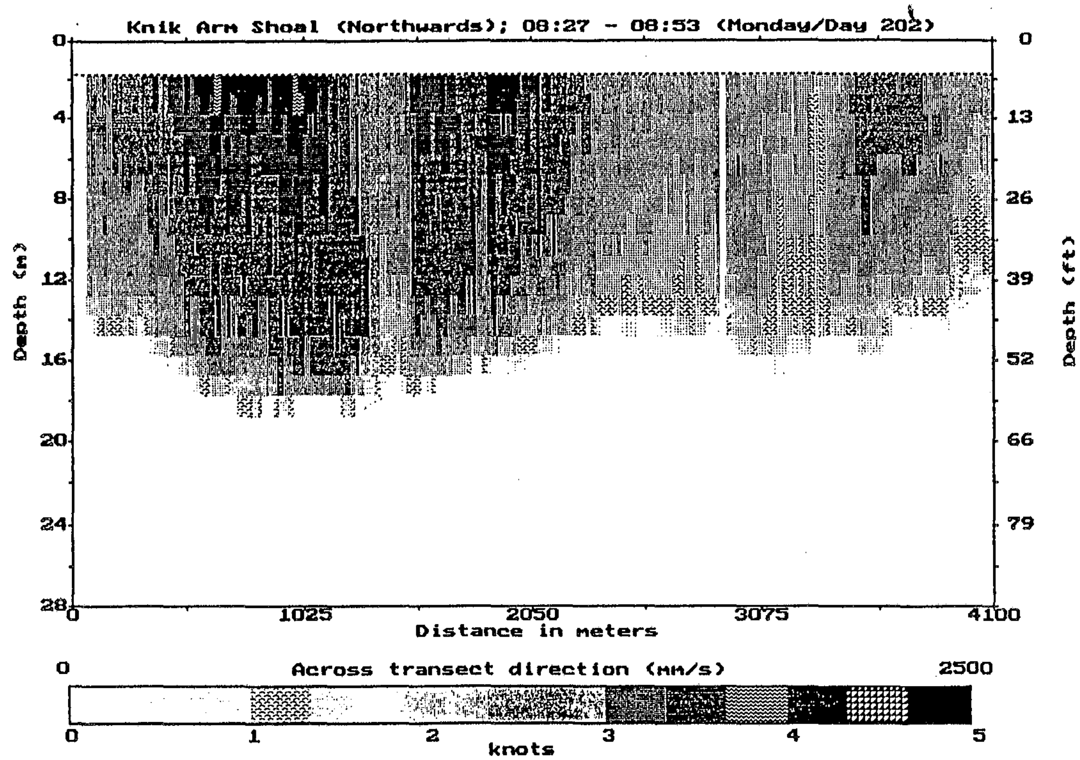

FIGURE B-17.--Consecutive vertical profiles of current speed at Knik Arm Shoal, normal to the southeast-northwest leg of the course of figure B-11, on a flood tide, July 20, 1992.

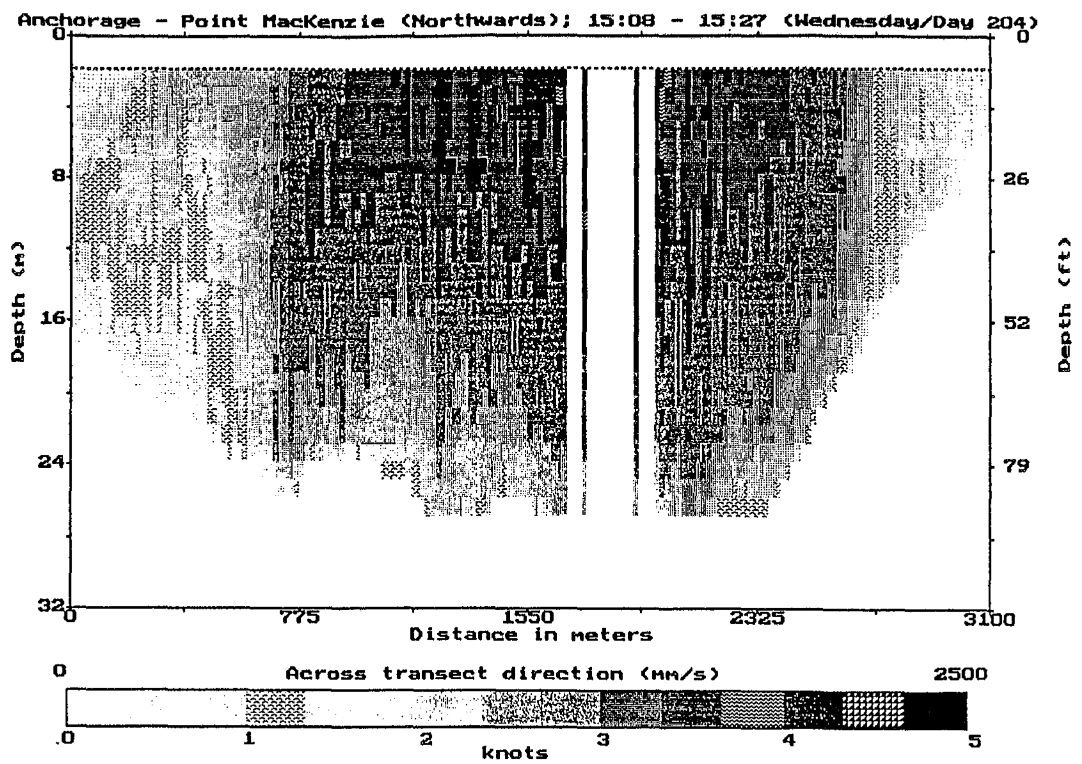

FIGURE B-18.--Consecutive vertical profiles of current speed across Knik Arm from the Port of Anchorage, normal to the course of figure B-13, on an ebb tide, July 22, 1992.

1.4.3 Water Properties. The distribution of water density is an indication of and can be a driving force for large-scale circulation. Density is controlled by the balance of temperature and salinity (the mass of dissolved solids per unit volume of water). The water of Knik Arm is brackish, with less salinity than lower Cook Inlet, but enough to indicate a significant exchange with water from lower Cook Inlet. Overall, salinities gradually increase as the Gulf of Alaska is approached (figure B-19). The vertical distribution of temperatures and salinity is of special interest, since many estuaries are marked by an intrusion of salty (denser) water near the bottom. This occurs in lower Cook Inlet and may occur to a lesser degree past the forelands in upper Cook Inlet. The tremendous tidal energy and strong mixing in the shallower water of Knik Arm prevents significant temperature or salinity stratification, except in the immediate vicinity of a river mouth. Suspended sediments can affect water motion in a manner equivalent to dissolved solids, especially when concentrations and concentration gradients (horizontal or vertical variations) are as high as they are in Knik Arm. The measurements and analyses of previous investigators and findings of the 1992 Corps measurements of temperature, salinity, and suspended sediment are reviewed in the following paragraphs.

1.4.3.1 Temperature and Salinity. The University of Alaska made extensive measurements of these water properties in 1968 across much of Cook Inlet, in association with pending oil and gas developments. Figure B-19 shows the distribution of surface salinity found in May 1968 (Kinney *et al.* 1970), which is representative of the findings of others (e.g. Evans *et al.* 1972, Gatto 1976, and Wapora 1979). Gatto (1976) provides an extensive review of prior temperature and salinity variations in Cook Inlet, with emphasis on lower Cook Inlet where direct exchange with the Gulf of Alaska occurs. Salinities generally increase from less than 10 parts per thousand (ppt) in Knik and Turnagain Arms to near 32 ppt at the Gulf of Alaska. Concurrent Cook Inlet surface temperatures were relatively uniform. Water temperatures in Cook Inlet are affected more by the season and the depth of the water than they are by circulation within the inlet, typical of many coastal and estuarine situations. Salinity variations tend to control density variations.

Salinities were measured by Everts and Moore (1976) in 1971 and 1972 on the tidal flats near the Port of Anchorage. Salinities generally ranged from 4 to 5 ppt during these summer measurements, with slight increases, typically less than 1 ppt, noted with the incoming tide. Bakus *et al.* (1979) measured two temperature and salinity profiles at high tide near Point Woronzof in July 1977, finding salinities from 3.7 to 5.6 ppt and temperatures from 14.5 to 15.7 °C. One low tide profile found uniform salinity at 8.8 ppt and temperatures from 15.5 to 16.8 °C. The tidal phases noted for these measurements may have been transposed, since the tidal variation in salinity is opposite the intuitive trend anticipated and that found by Everts and Moore (1976) with more extensive measurements.

Temperature and salinity profiles were measured by the Corps of Engineers in July 1992, using a continuously recording conductivity, temperature, and pressure (depth) sensor (CTD) assembly which was lowered from a launch off the NOAA ship *Rainier*.

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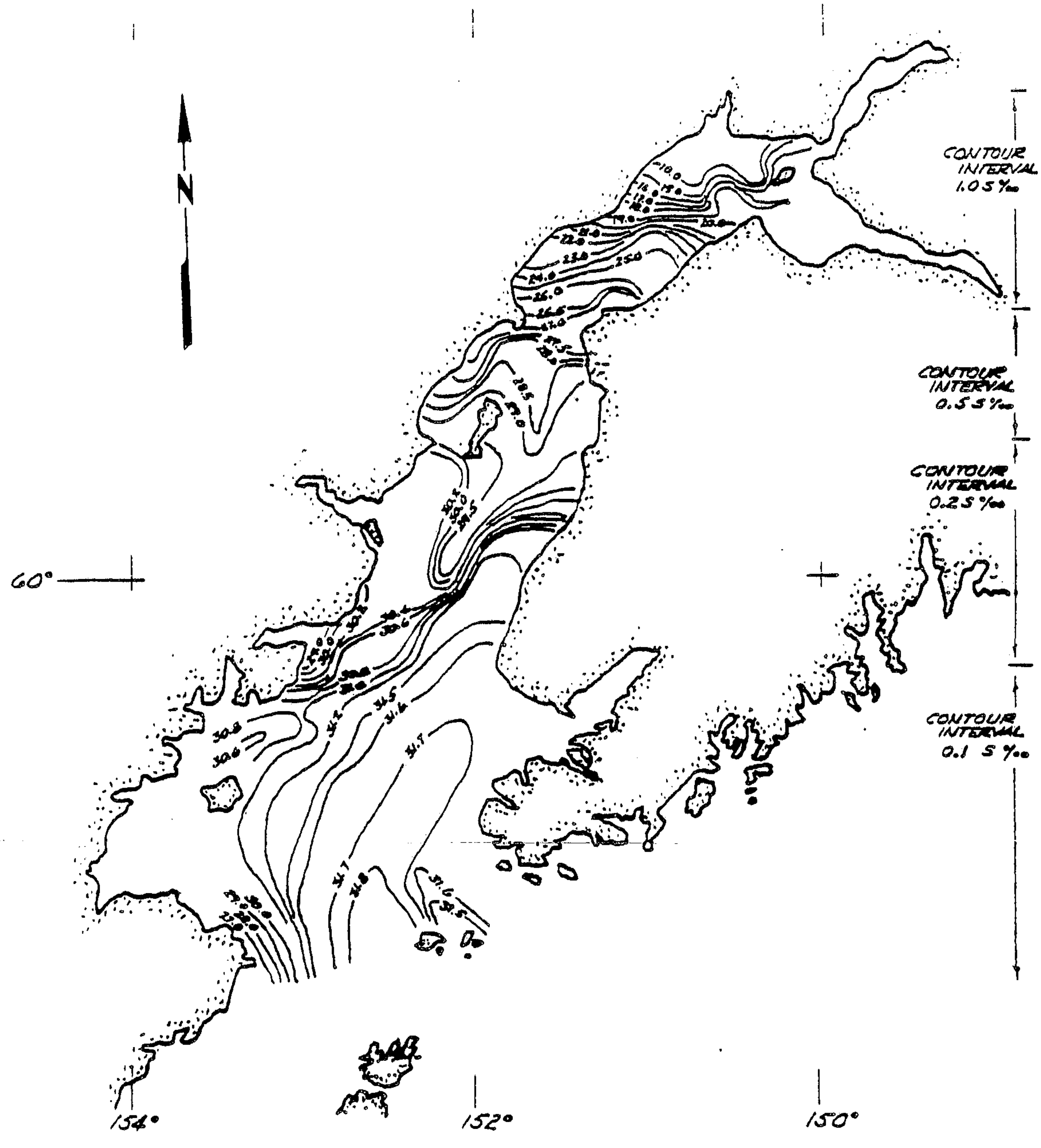

TYPICAL DISTRIBUTION OF SURFACE SALINITIES

Source: Kinney *et al.* 1968
N.T.S.

US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

B-19

Locations of CTD profiles are noted on figure B-20. Samples of plotted profiles of temperature, salinity, and density as sigma-t are presented in figures B-21 to B-25. Sigma-t is the water density in kg/m^3 (e.g. 1,005 kg/m^3), less the density of fresh water (1,000 kg/m^3). The "-t" implies that the density measured at depth is converted to its equivalent value at the surface, but pressure effects on density in coastal waters are insignificant.

The profiles of figure B-21 were measured during ebb tide flows along the present shipping route northwest of Fire Island, showing a temperature gradient in the upper 2 m contributed by outflow of the Little Susitna River. Salinity changes more gradually from the surface downward with an overall increase of about 1 ppt (8.5 to 9.5 ppt). Density follows a trend identical to that of salinity in this case.

Figure B-22 shows measurements made during ebb tide flows north of Race Point on Fire Island, with temperature decline at the surface and another sharp variation at 5 to 6 m. The temperature sensor was extraordinarily sensitive, so variations of a few tenths of a degree, as shown here, were detectable. This small temperature difference is not enough to have a significant effect on density, as indicated by the sigma-t profile's adherence to the salinity trends. It is, however, an indication of non-uniform vertical mixing in the complex flows of Knik Arm.

Figure B-23 shows measurements made during ebb tide flows just south of Knik Arm Shoal, in the vicinity of the proposed channel. The conditions at the time of the measurement included a distinct stratification of warmer, fresher water in the upper 2 to 3 m over slightly colder, saltier uniform water below.

Figure B-24 shows measurements made during flood tide flows offshore of the Port of Anchorage. Both temperature and salinity increased slightly with depth at this time and place. Sigma-t is computed directly from temperature and salinity, again following the salinity trend exactly. Some influence of Ship Creek outflow and city runoff may be seen here, but the apparent inversion of the temperature gradient from intuitive expectations also may be related to effects of suspended sediment gradients, complex localized circulation, or a combination of these factors.

Figure B-25 shows measurements made during flood tide flows off Cairn Point, with uniform temperature, salinity, and density from the surface to 20 m depth. The hydraulic constriction here may tend to render water properties to be uniform with depth.

Salinities are seen from these and other July 1992 measurements to vary from nearly 13 ppt to 7 ppt, generally decreasing from west of Fire Island to north of Cairn Point. July temperatures were between 14 and 15 °C, occasionally sharply varying with depth for a few tenths of a degree. Salinity controls density, but little significant stratification is evident. Occasional evidence of freshwater flow above saltier water below occurs, but the stratification does not appear significant enough to measurably affect the dominant tidal forcing of flow in Knik Arm. Thermohaline circulation plays a measurable role in

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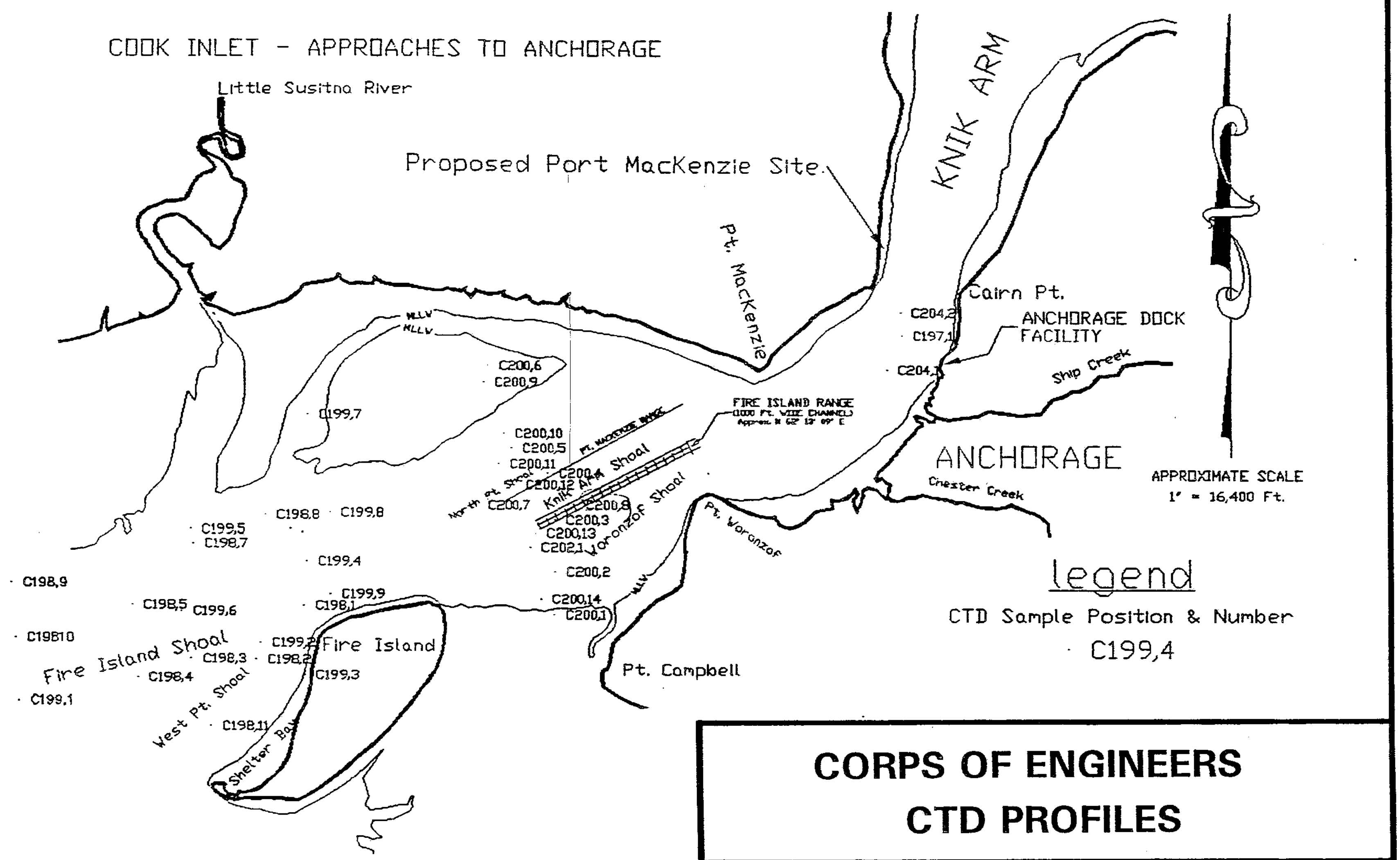

NOTES: Locations and cast numbers of conductivity (salinity), temperature, and optical backscatter profiles, July 1992. MLLW contour is from 1982 soundings.

CORPS OF ENGINEERS
CTD PROFILES

US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

B-20

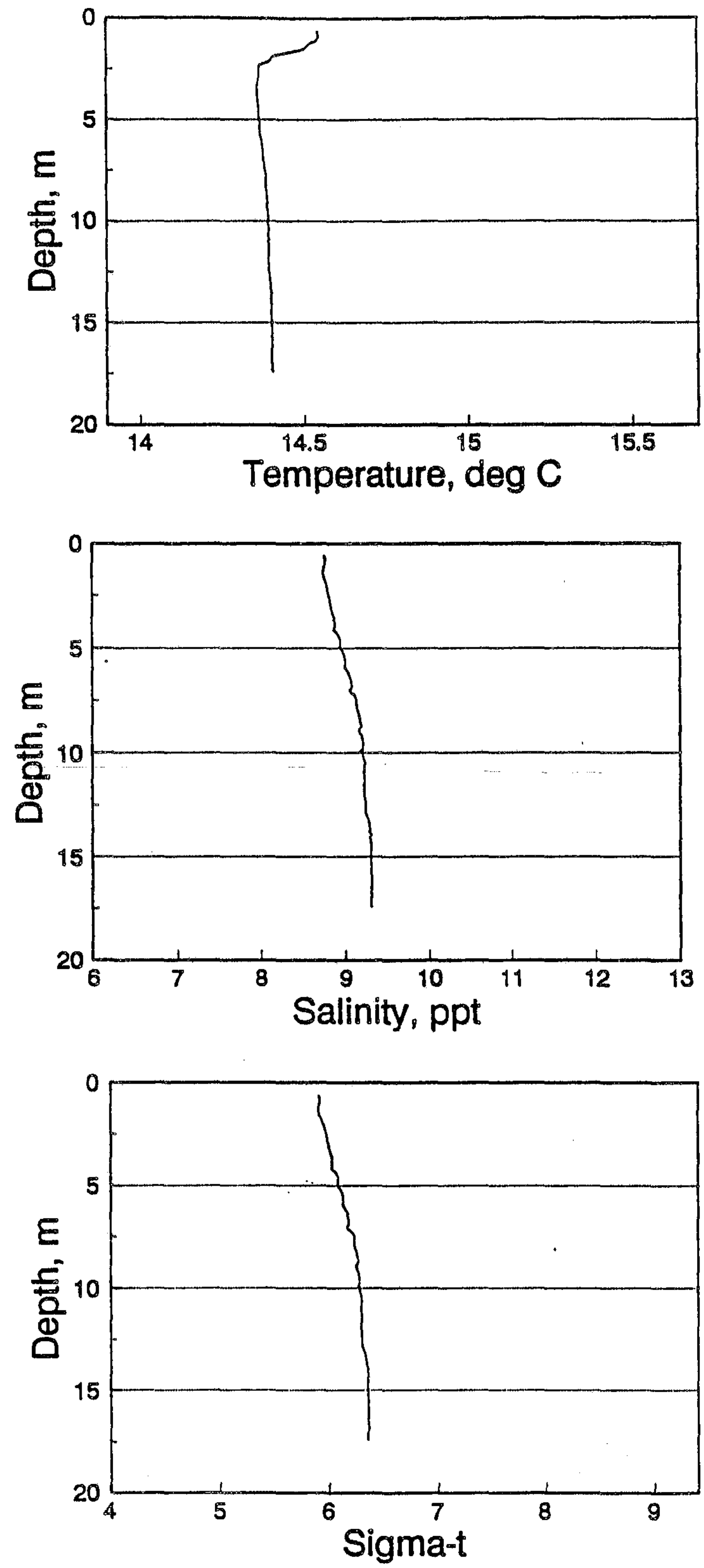

FIGURE B-21.--Water property profiles from Cast No. C198,10 at 1017 (ebb tide) on July 16, 1992, 5-1/2 miles west of Race Point on Fire Island.

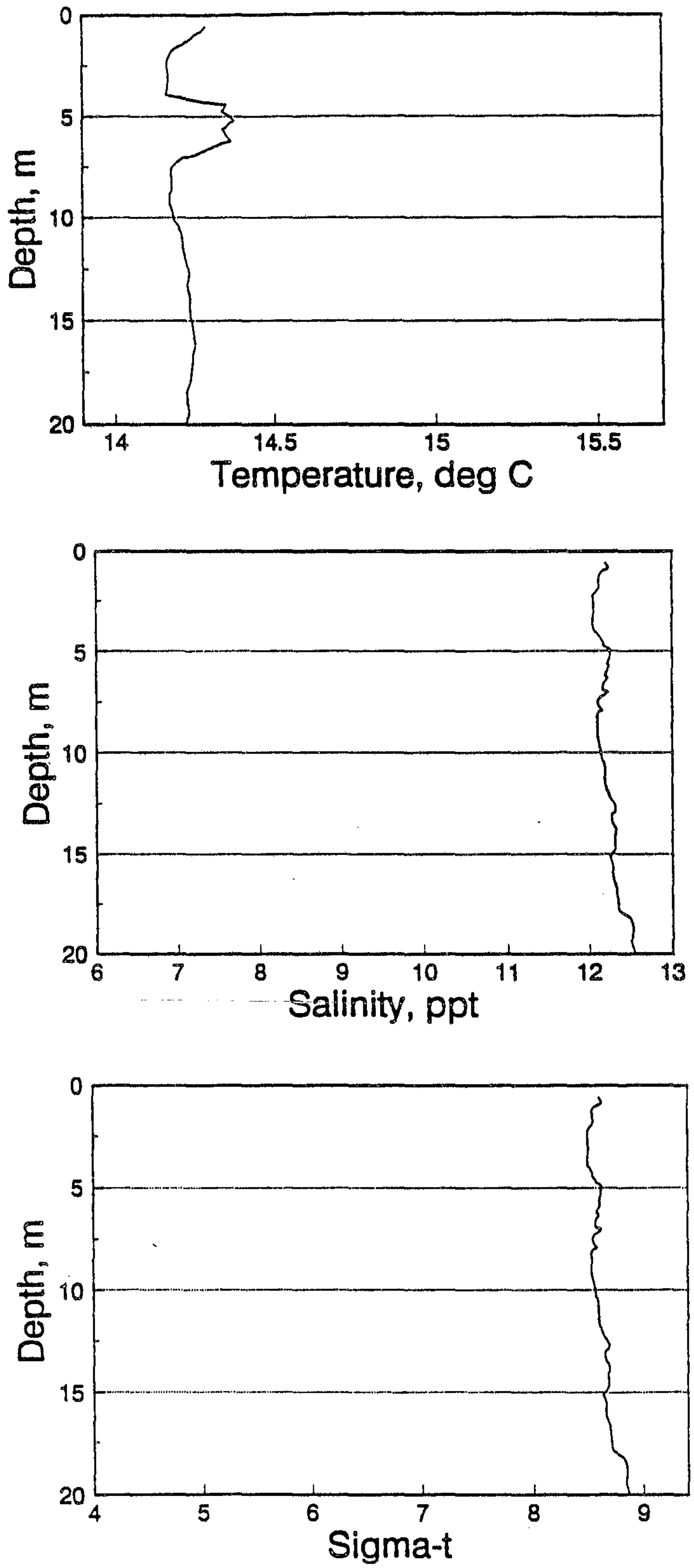

FIGURE B-22.--Water property profiles from Cast No. C199,4 at 1101 (ebb tide) on July 17, 1992, 1-1/2 miles north of Race Point on Fire Island.

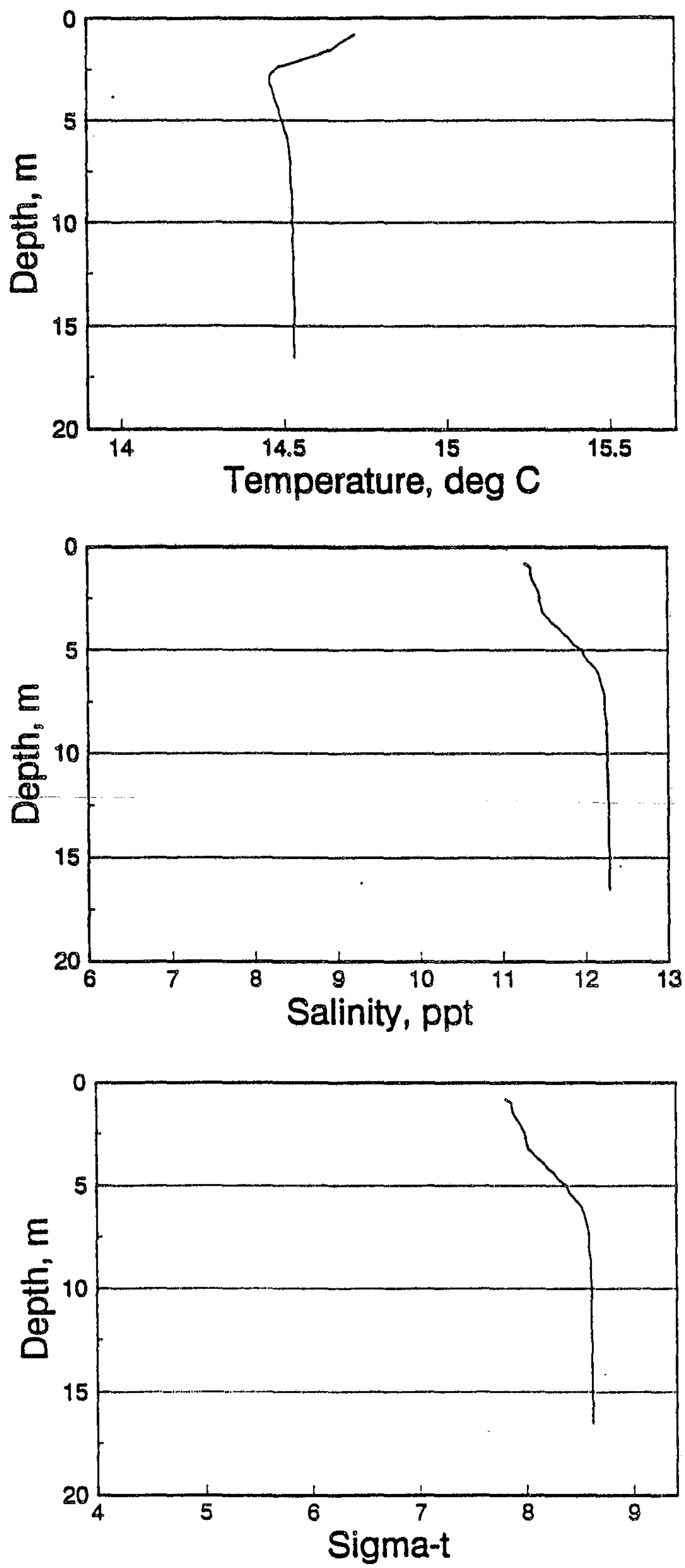

FIGURE B-23.--Water property profiles from Cast No. C200,8 at 1053 (ebb tide) on July 18, 1992, 2 miles west of Point Woronzof on the south side of Knik Arm Shoal.

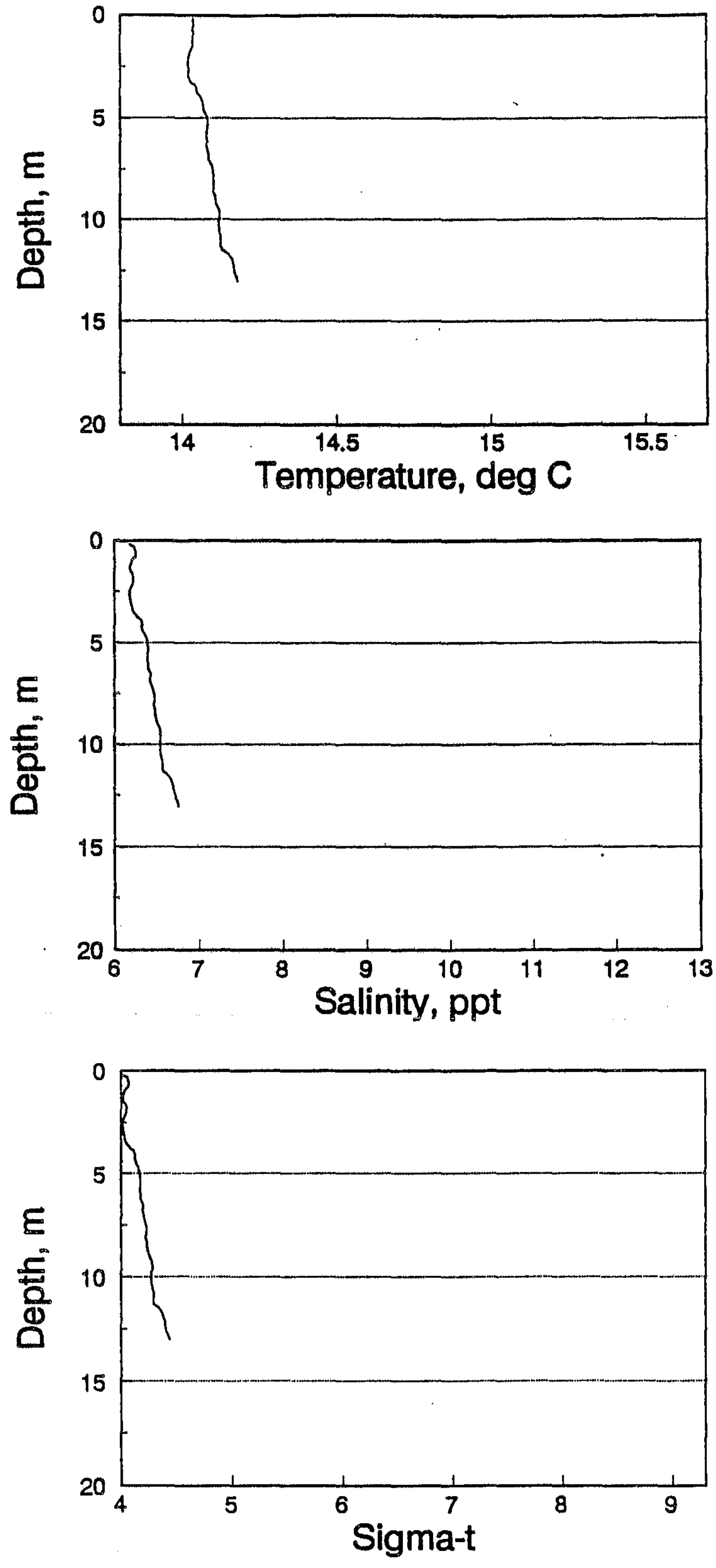

FIGURE B-24.--Water property profiles from Cast No. C204,1 at 0857 (flood tide) on July 22, 1992, 3/4 mile offshore of the Port of Anchorage.

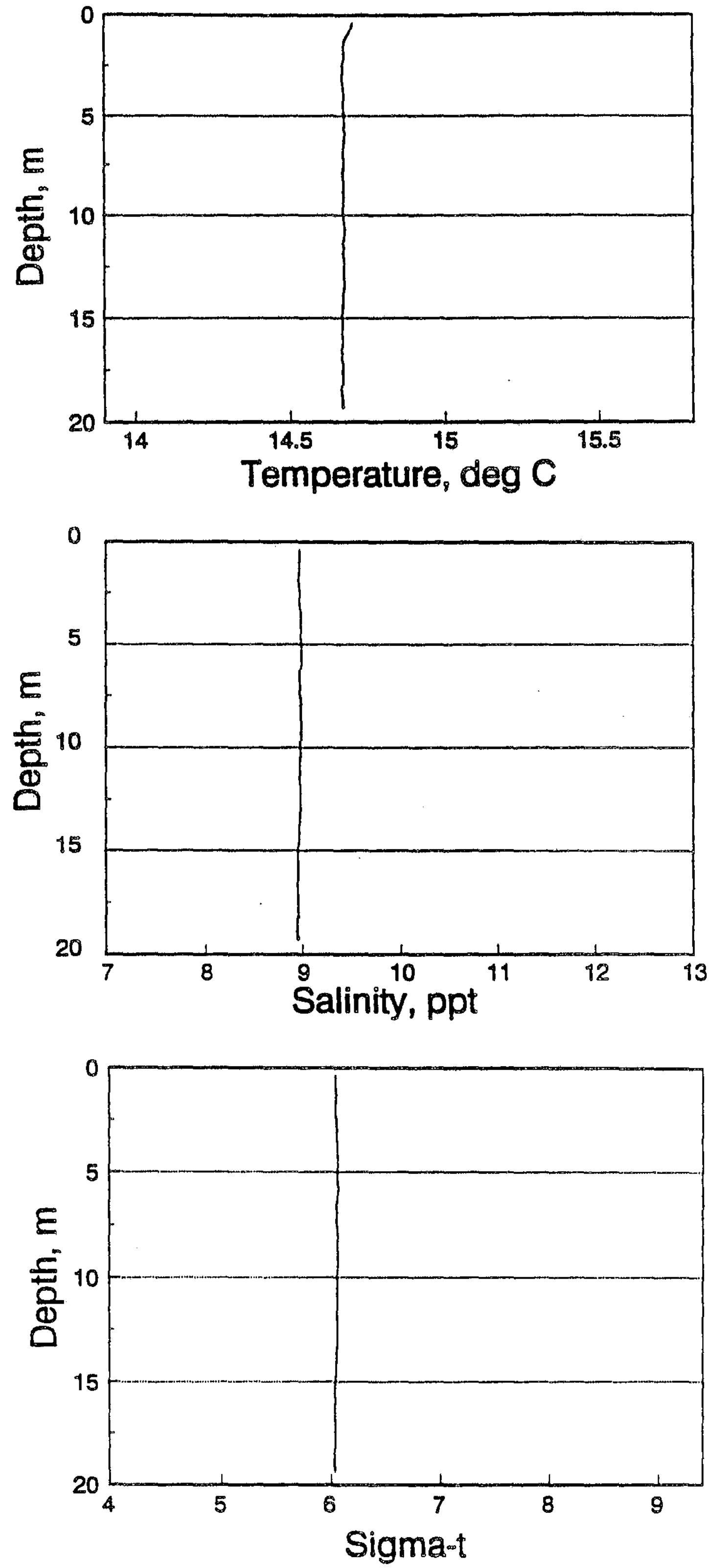

FIGURE B-25.--Water property profiles from Cast No. C204,2 at 1137 (flood tide) on July 22, 1992, 1 mile west-southwest of Cairn Point in Knik Arm.

lower Cook Inlet, but this does not appear to affect either currents or sedimentation patterns in Knik Arm.

1.4.3.2 Suspended Sediments. The waters of Cook Inlet are increasingly turbid northward, at times reaching remarkable levels of suspended sediment concentrations in excess of 3,000 mg/l in Knik Arm. Suspended sediment concentrations in Knik Arm in excess of 1,000 mg/l are routine and, where gradients are large, may affect water motion. Suspended sediment concentration is not truly a water property, but high values can cause a water mass to behave as if the water itself were denser due to an increased sediment load. High concentrations are known to enhance particle fall velocities to over 10 times higher than their theoretical values (Johnson 1990). Furthermore, the suspended sediment provides a virtually unlimited supply of material for shoaling where conditions allow long-term settlement. This is nowhere more apparent in Cook Inlet than at the Port of Anchorage, where about 220,000 cubic yards of silt are removed each year due to settlement in the maneuvering area excavated to -35 ft MLLW in front of the dock.

Satellite imagery is particularly useful in identifying turbid waters, which in turn identify circulation trends responsible for their distribution. Figure B-26 shows a generalized view of surface suspended sediment concentrations in Cook Inlet (Gatto 1976). These concentrations reveal the Coriolis-induced trend which concentrates clear salty water from the Gulf of Alaska along the eastern shore of lower Cook Inlet and distributes fresher, more turbid water along the western shore. The grain size of materials found in suspension also increases northward with concentrations. Both are related to the relative energy of tidal turbulence which maintains the sediment in suspension. Freshwater flow and sediment supply from rivers affect suspended sediment concentrations, so a seasonal cycle exists with highest turbidities in the high-runoff spring and summer seasons. Tidal energy also varies, most notably on a (lunar) monthly cycle. Everts and Moore (1976) noted a correlation of concentrations with tidal range at Anchorage. Concentrations have also been noted to increase with depth (Gatto 1976), presumably due to a combination of settling, decreased turbulence as bottom friction effects become more pronounced, and active resuspension of bottom materials.

Suspended sediment concentrations were measured directly from 6.2-liter samples collected by the Corps of Engineers in July 1992 with the assistance of the NOAA ship *Rainier*. Figure B-27 shows the location of these samples and notes the depths at each site where discrete samples were collected. Suspended sediment concentrations and sediment grain size distributions were measured for each sample (Naidu *et al.* 1992). Most samples were roughly half silt and half clay-sized particles. Some samples included a small fraction of fine sand.

The sample data were applied to calibrate both acoustic and optical measurements of suspended sediment concentration. An optical backscatter sensor (OBS) was lowered in conjunction with each CTD cast (see figure B-20). The sensor emitted pulses of infrared light and sensed the reflection of nearby particles in the water. This device is known to be useful in high turbidities, such as those encountered in upper Cook Inlet. Sample concentrations allowed the signal of the OBS sensor to be calibrated in units of concentration, thus providing concentration profiles. Figure B-28, corresponding to the water properties of figure B-21, indicates a uniform concentration of about 400 mg/l at this site west of Fire Island. Figure B-29, corresponding to figure B-22, shows concentrations less than 100 mg/l to 10 m depth, increasing below that to 1,300 mg/l at 32 m depth. Figure B-30, with conditions corresponding to figure B-23, shows a sharp gradient of concentration near the surface from less than 100 mg/l to a fairly uniform concentration below of 600 to 900 mg/l. Figure B-31, corresponding to figure B-24, shows a steady increase of concentration from the surface at 600 mg/l to a uniform concentration of 1,400 mg/l below 4 m depth. Figure B-32, corresponding to figure B-25, shows erratic values in the top 1.5 m (600 to 900 mg/l) and a sharp gradient at 2 m to a uniform concentration of 1,100 mg/l to 20 m depth. The most notable aspect of the OBS concentration data was the extraordinary variation in all dimensions. Additional analysis is required to relate these changes specifically to tidal or bathymetric variations.

A second means of measuring suspended sediment concentrations was applied during the July 1992 measurements involving a Corps-sponsored modification to the ADCP system. The normal configuration for the acoustic transducers looking down into the water is an array of four transducers angled 30° outward from the vertical, two fore-and-aft and two athwartships. The unit used in Cook Inlet was modified to include a fifth beam looking down in the center of the ADCP array (see figure B-33). The center beam was not used for current measurements, but was instead dedicated to precise detection of echo amplitude as a measure of reflector density, *i.e.*, suspended sediment concentration. This method has been developed by the U.S. Army Engineer Waterways Experiment Station as a means to monitor dispersion of dredged material disposal plumes (Kraus 1991). Concentrations measured from water samples were applied to calibrate the acoustic measurements in units of mg/l (Lohrmann and Brumley 1992).

Gray-scale plots of concentration were plotted in the same way as current speeds normal to cruise tracks. Figures B-34 to B-36 show concentrations measured at the same time as the currents of figures B-16 to B-18. These plots did not reproduce well in black and white, but the color versions, which can be viewed on a computer monitor, provide a striking view of concentration variations. Episodes of sediment resuspension can be seen on the flanks of the shoal, apparently related to the secondary circulation revealed by the coincident current measurements made by the same instrument. Vertical and horizontal variations are significant, often revealing circulation trends which are otherwise a challenge to discern from current data.

Conclusions that can be drawn include the fact that concentrations are high enough and gradients strong enough in places that the sediment load itself may induce changes in the flow. Bottom sediment sample data and current data observations, combined with intermittent (but common) incidences of high concentrations suspended above lower concentrations, imply that fine materials do not settle in the area of Knik Arm Shoal. Turbulent energy is seen to be consistently strong enough to maintain all but the coarsest

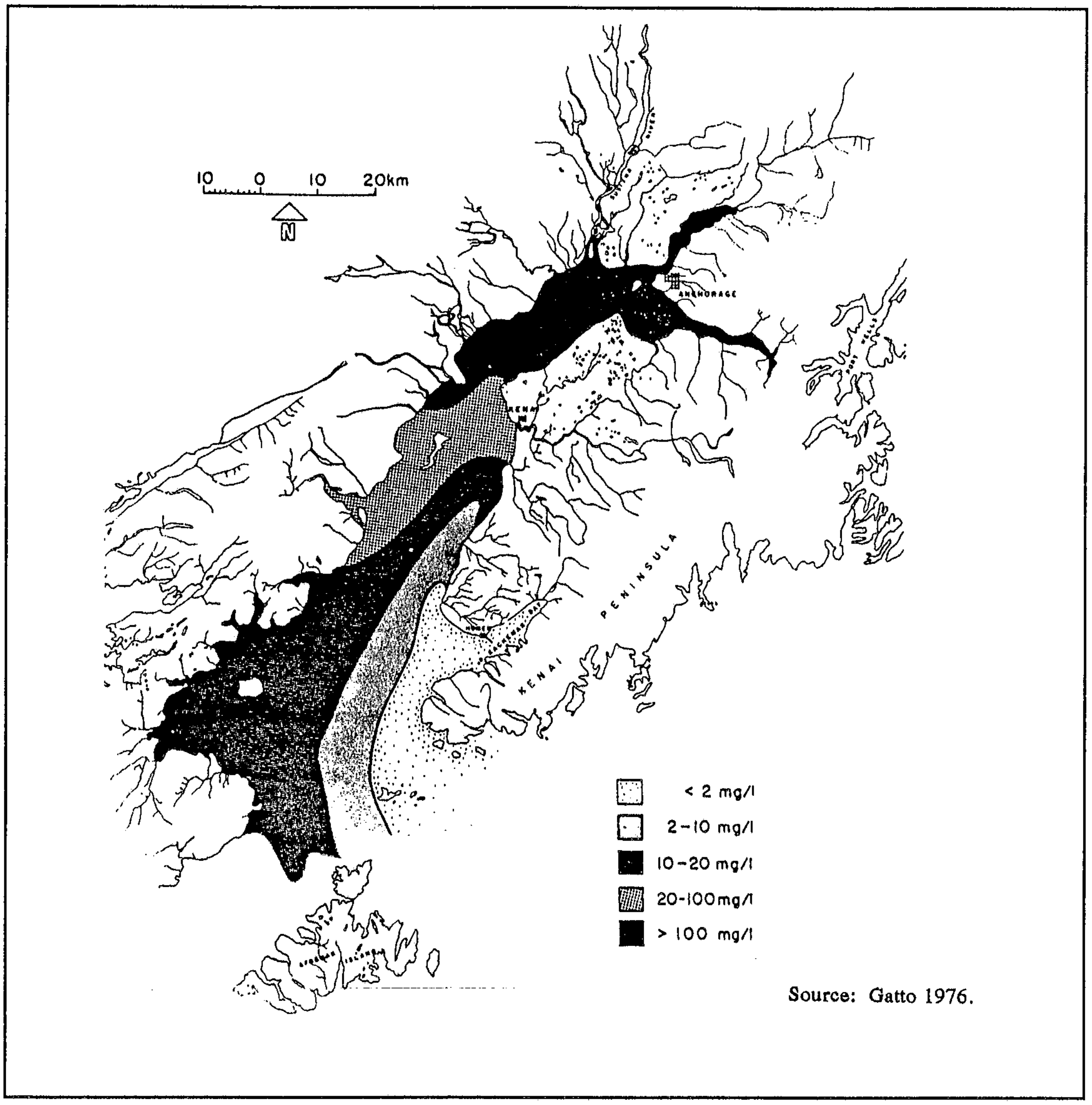

FIGURE B-26.--Typical surface suspended sediment concentrations in Cook Inlet.

material in suspension all across this part of Knik Arm below the intertidal zone and some distance up into the intertidal zone. Resuspension of sediments on the flank of shoals occurs constantly, in places rising several meters off the bottom, even in the deepest areas of the measurements (see figures B-34 to B-36). Since a relation to secondary flow is apparent, the assumptions inherent in many hydraulic models, especially those which predict only vertical averages of currents, will not be able to account explicitly for this aspect of sediment transport.

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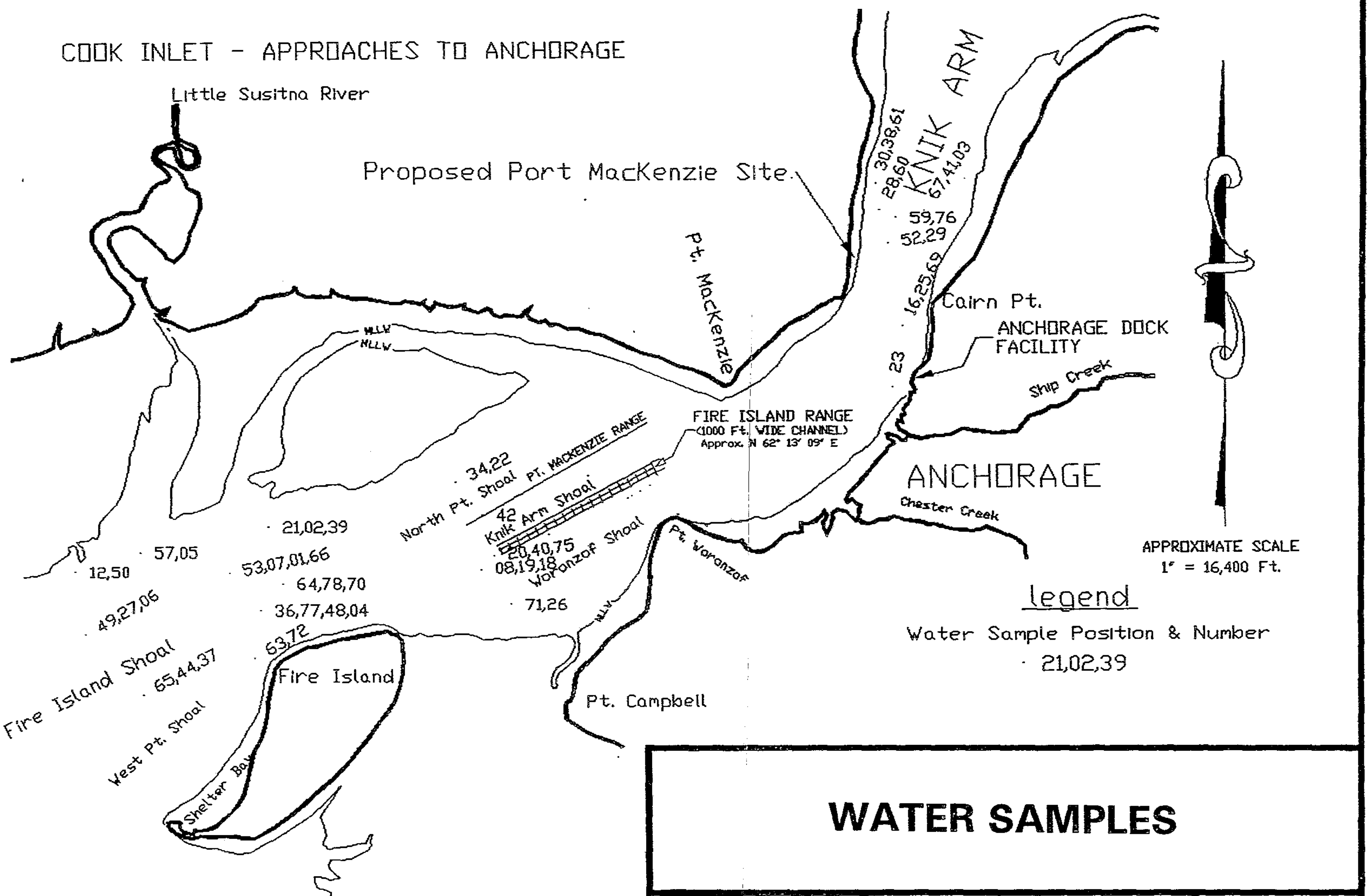

Note: MLLW contour is from 1982 soundings

WATER SAMPLES

US Army Corps of Engineers
Alaska District

COOK INLET
NAVIGATION

B-27

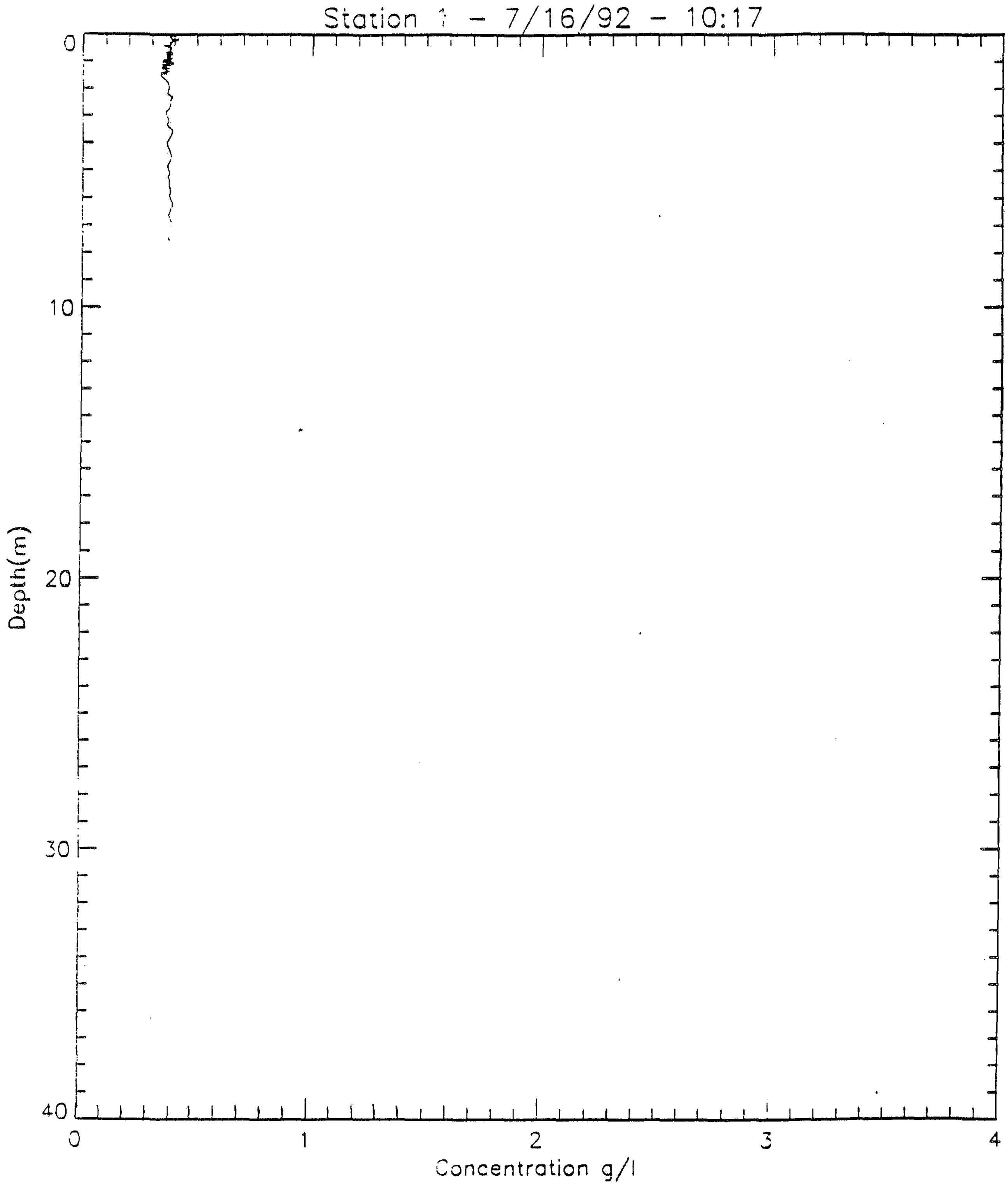

FIGURE B-28.--Profile of suspended sediment concentration from optical backscatter data, Cast No. C198,10 at 1017 (ebb tide) on July 16, 1992, 5-1/2 miles west of Race Point on Fire Island (see figure B-21).

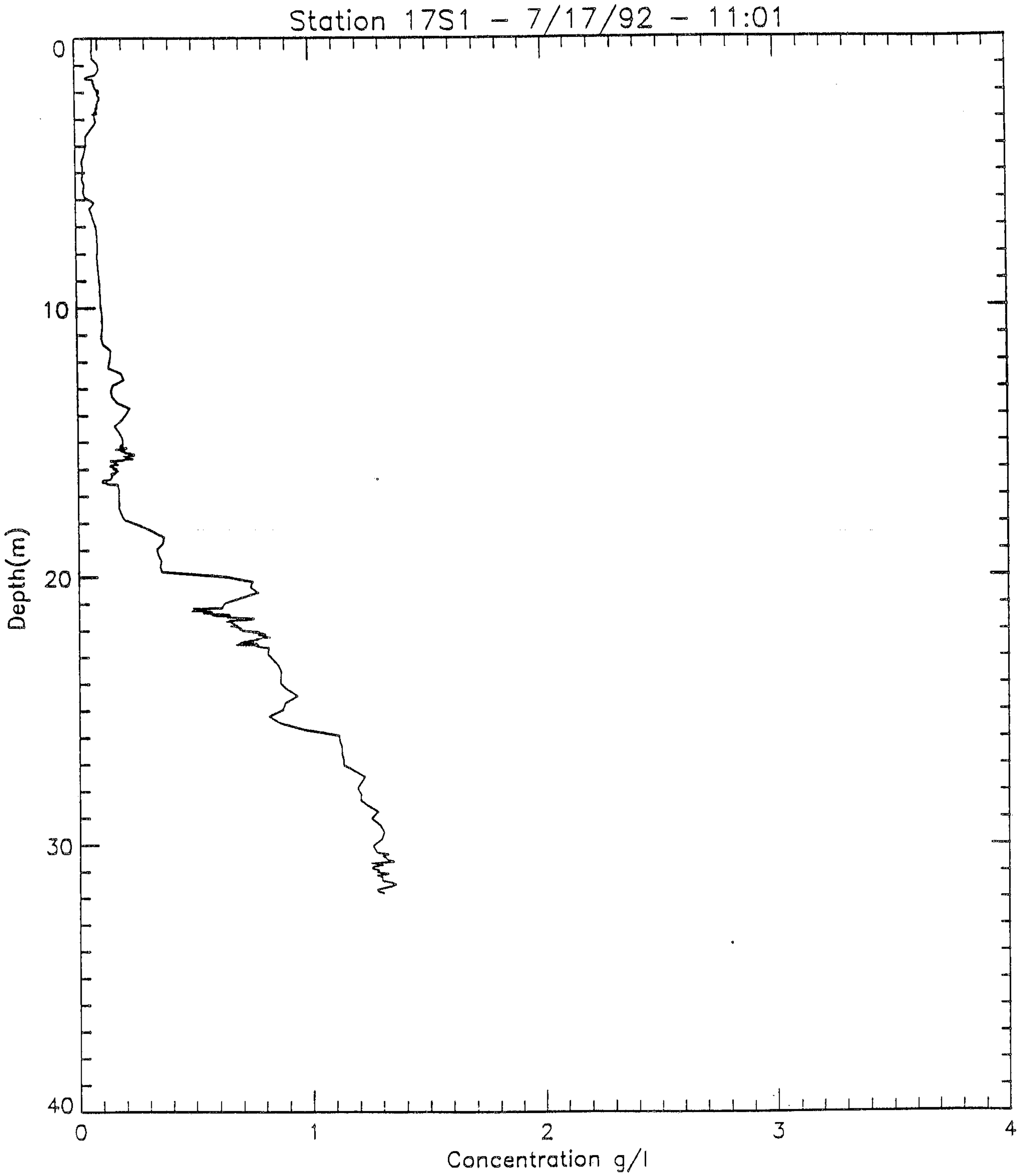

FIGURE B-29.--Profile of suspended sediment concentration from optical backscatter data, Cast No. C198,10 at 1017 (ebb tide) on July 16, 1992, 5-1/2 miles west of Race Point on Fire Island (see figure B-22).

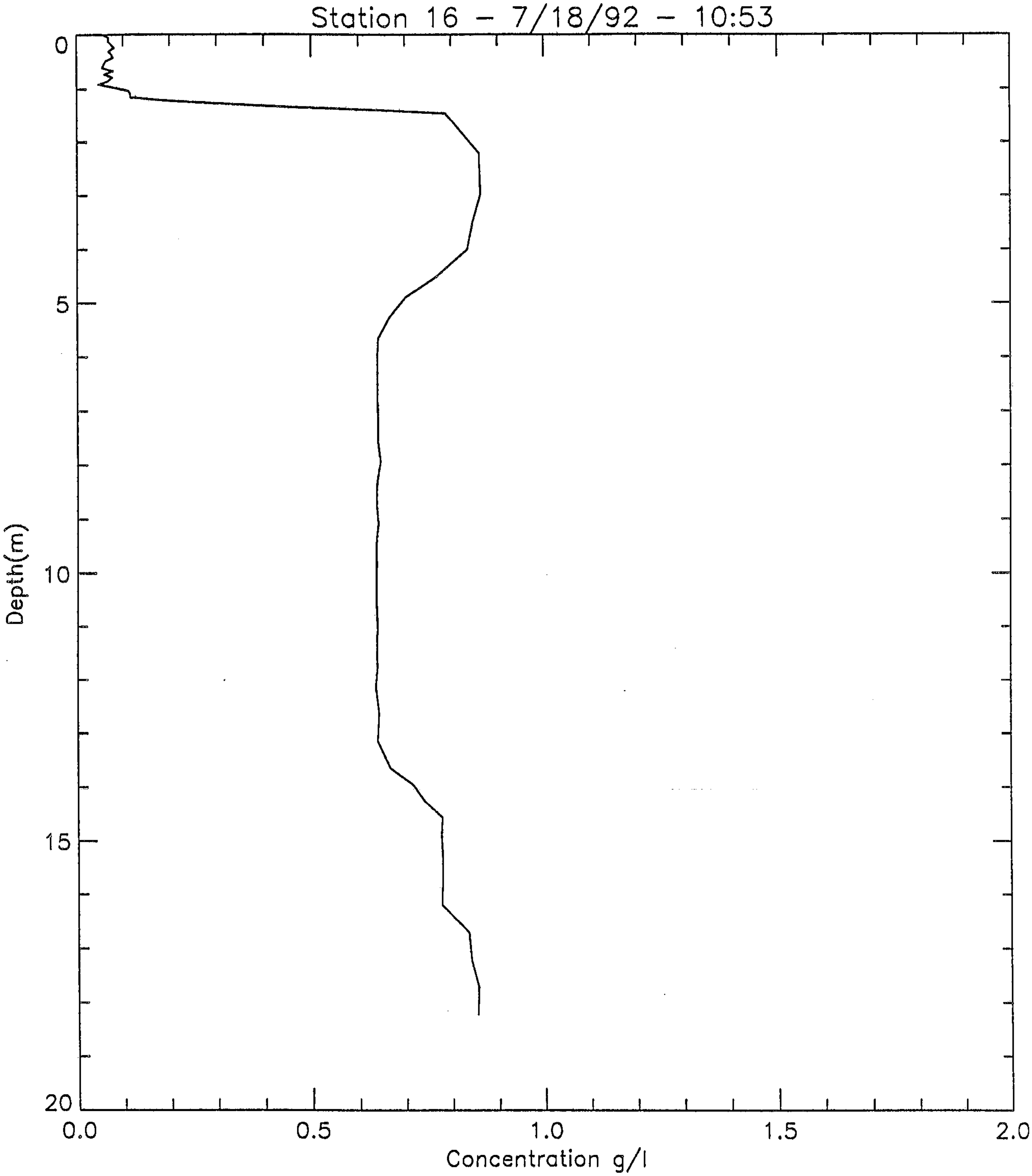

FIGURE B-30.--Profile of suspended sediment concentration from optical backscatter data, Cast No. C200,8 at 1053 (ebb) on July 18, 1992, 2 miles west of Point Woronzof, south side of Knik Arm Shoal (see figure B-23).

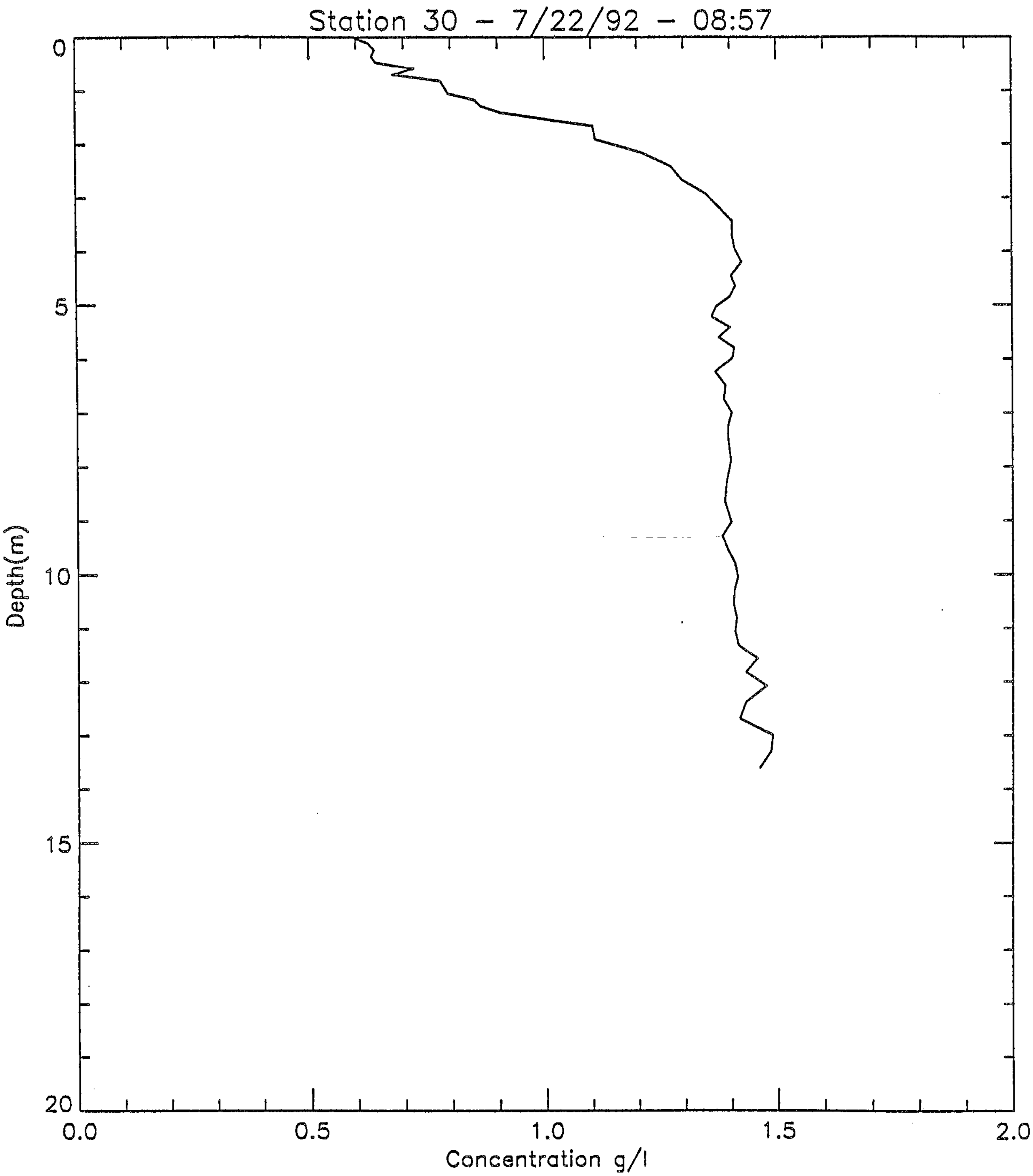

FIGURE B-31.--Profile of suspended sediment concentration from optical backscatter data, Cast No. C204,1 at 0857 (flood tide) on July 22, 1992, 1 mile west-southwest of Cairn Point in Knik Arm (see figure B-25).

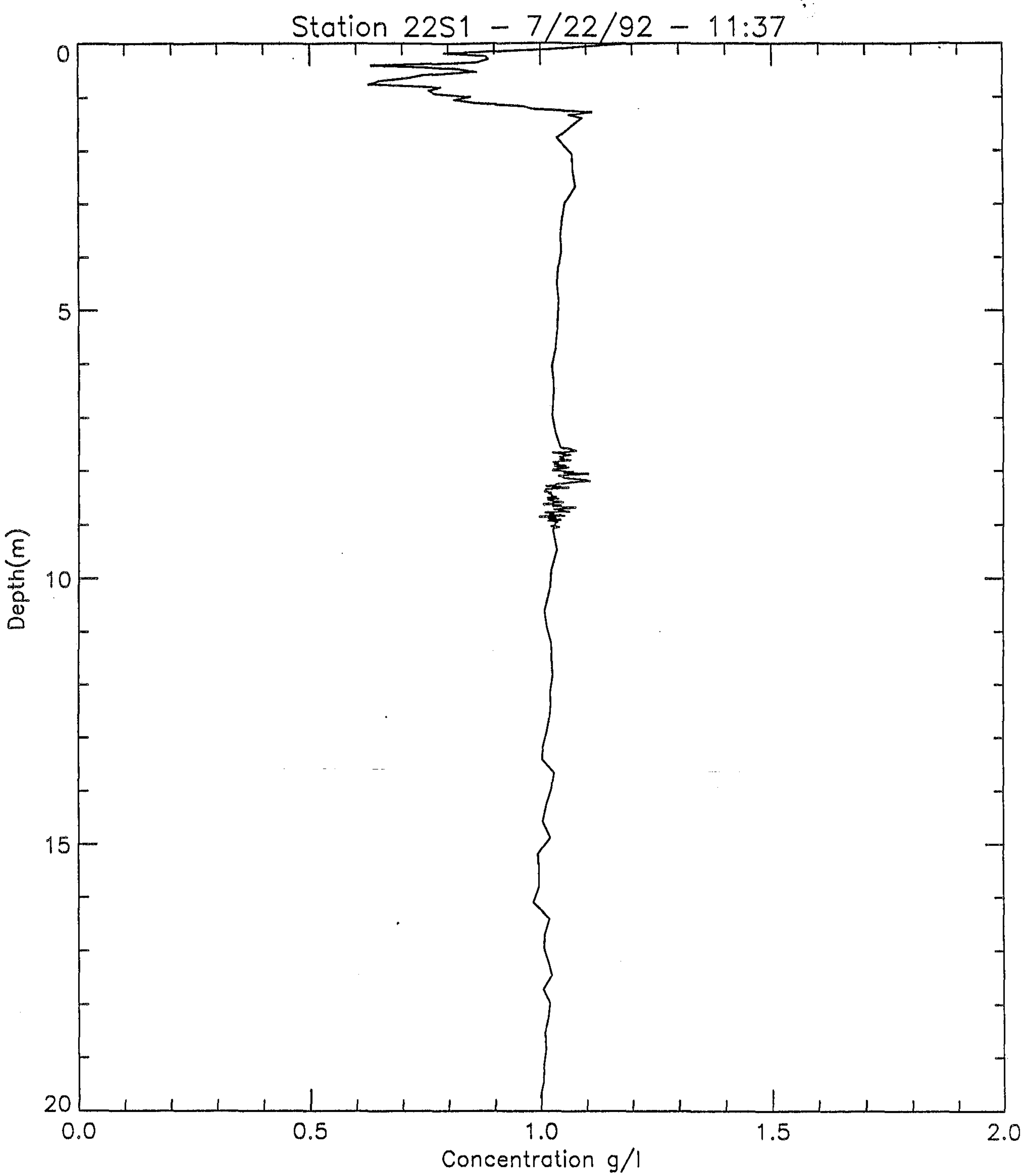

FIGURE B-32.--Profile of suspended sediment concentration from optical backscatter data, Cast No. C204,2 at 1137 (flood tide) on July 22, 1992, 1 mile west-southwest of Cairn Point in Knik Arm (see figure B-25).

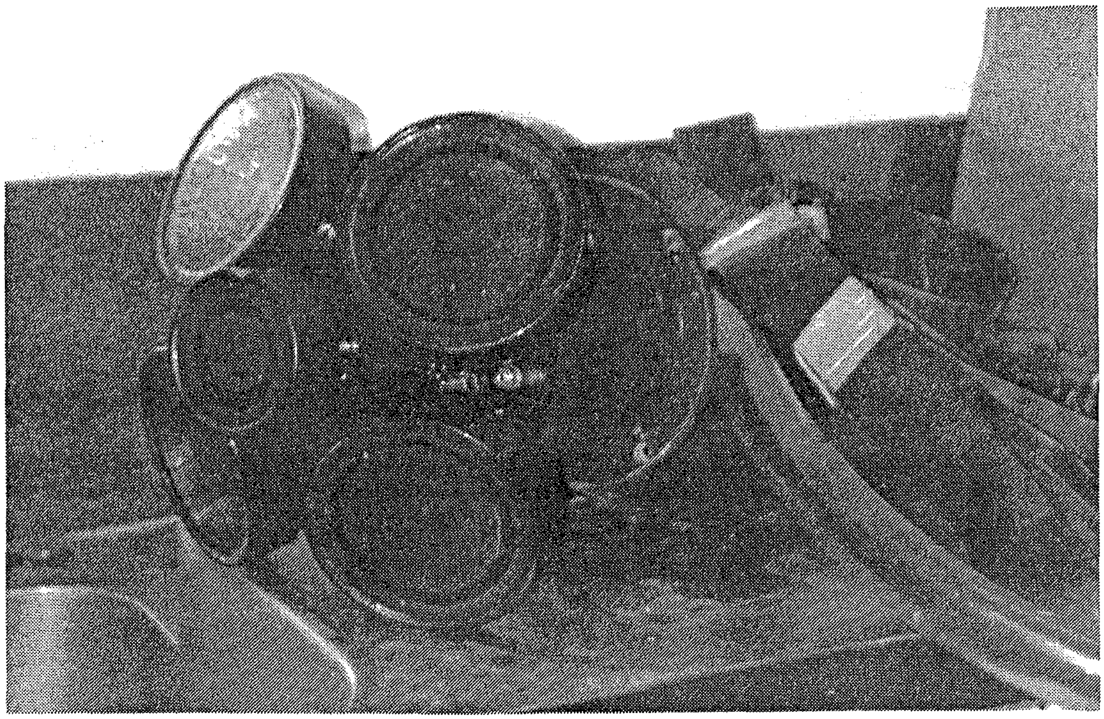

FIGURE B-33.--Five-beam ADCP transducer used in Corps of Engineers measurements of current profiles (outer four beams) and suspended sediment concentration (central beam) in upper Cook Inlet, July 1992.

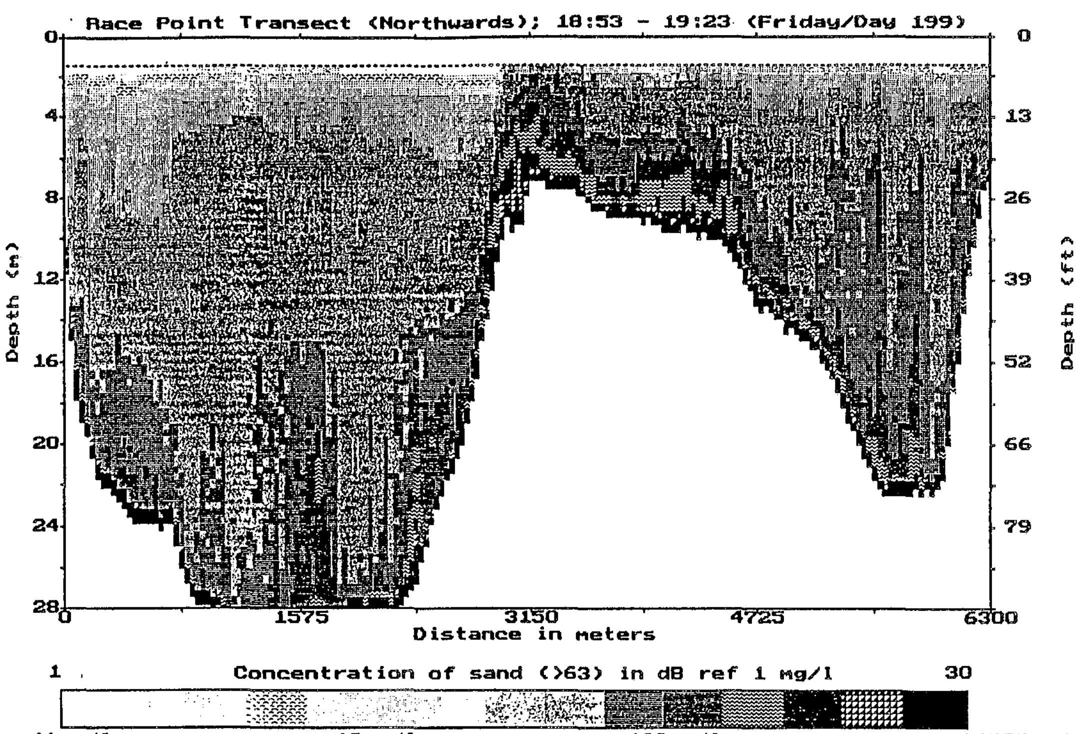

FIGURE B-34.--Consecutive profiles of suspended sediment concentration from acoustic echo amplitude data, along the course of figure B-10, across Knik Arm from Race Point on Fire Island on a flood tide, July 17, 1992.

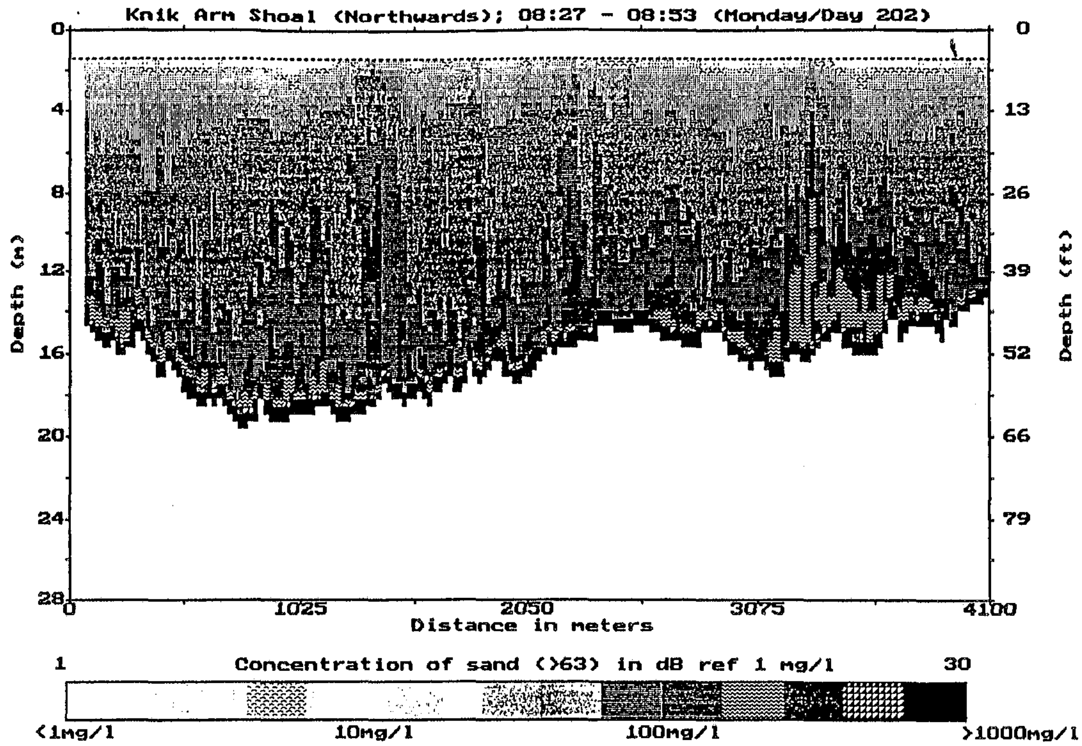

FIGURE B-35.--Consecutive profiles of suspended sediment concentration from acoustic echo amplitude data, at Knik Arm Shoal, along the southeast-northwest leg of the course of figure B-11, flood tide, July 20, 1992.

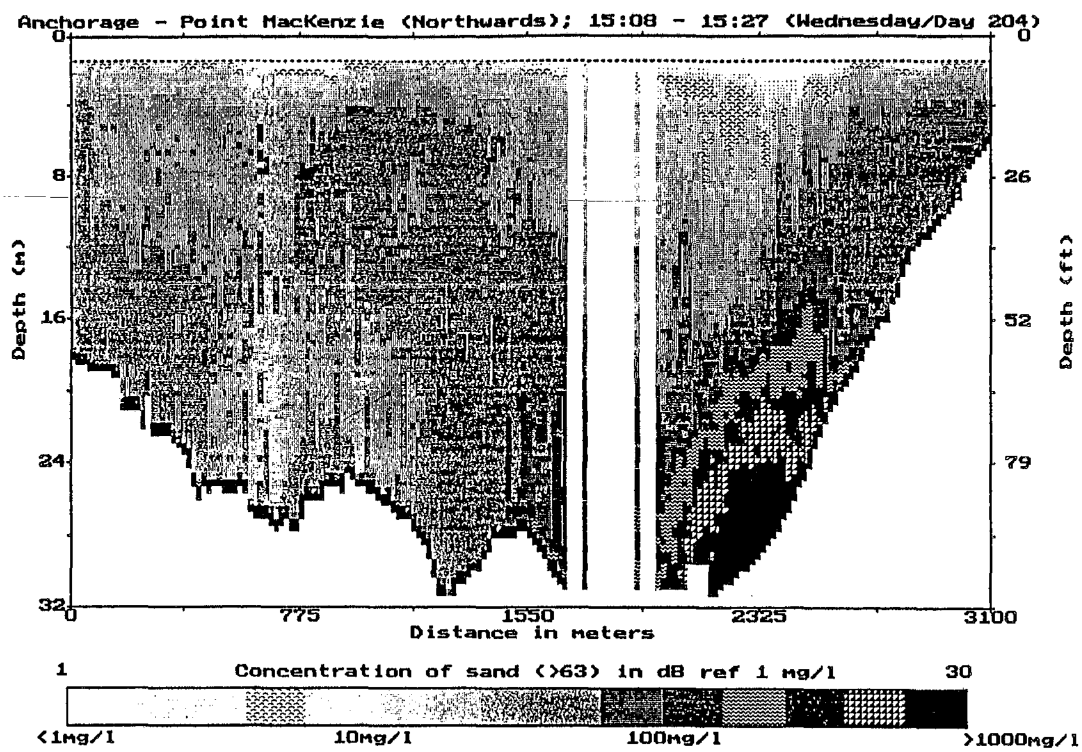

FIGURE B-36.--Consecutive profiles of suspended sediment concentration from acoustic echo amplitude data, across Knik Arm from the Port of Anchorage, normal to the course of figure B-13, on an ebb tide, July 22, 1992.

2. CHANNEL DESIGN

2.1 Deep Draft Vessels

Considerations for channel design followed the standards of Engineering Regulation (ER) 1110-2-1404, "Deep Draft Navigation Project Design" (USACE 1981), as well as other pertinent guidance. The first consideration is to define the fleet of vessels likely to use the prospective channel improvement. Vessels now serving the Port of Anchorage include container ships; liquid-bulk ships carrying petroleum products, cement, asphalt, and occasionally other liquid products; dry-bulk ships carrying logs; and a variety of barges and smaller break-bulk carriers. The port is visited by Navy and tour ships a few times per year. There appears to be a serious prospect of Panamax-class coal carriers visiting either the proposed new Port MacKenzie, across Knik Arm from the Port of Anchorage, or a northward expansion of the existing port. Dimensions of vessels representative of the above fleet are presented in table B-1. A more complete set of vessel dimensions is available in Appendix D, Ship Transit Simulation, as applied in

TABLE B-1.--*Deep draft vessel dimensions (ft)*

Shipper/*Vessel*	Length overall	Beam	Loaded draft
Sea-Land *Tacoma*	710	78	34.3
Tote *Greatland*	790	105	29.0
Chevron tanker	651	96	36.7
ABI (cement)	524	83	33.5
Almar (tanker)	600	106	37.0
Almar (tanker)	620	80	27.0
Stellar Bleny[1]	557	89	32.0
Green Kobe[1]	569	82	31.7
Hans Olendorf[1]	495	85	32.9
Idemisu-Kosan *Daphne Ocean*[2]	745	106	43.3

[1] Log ships serving regional Alaskan ports.
[2] Panamax coal ship.

simulations of ship transits through Cook Inlet to and from the Port of Anchorage. Loaded draft refers to the maximum draft at the design load water line. Vessels now serving the Port of Anchorage in practice rarely load themselves to draw more than 32 ft, since the dock and maneuvering area immediately in front are dredged once a year to -35 ft MLLW and are shallower at other times. The dimensions chosen for the design vessel are a length of 800 ft, a width of 106 ft, and a static draft of 32 ft in Knik Arm waters. This size encompasses all but the Panamax coal carriers which may soon serve upper Cook Inlet. The effect of channel improvements on Panamax coal ships was simulated, however, and results are discussed in appendix D.

2.2 Channel Location

The least controlling depth along the approaches to Anchorage occurs at Knik Arm Shoal. Fire Island Shoal, with a controlling depth of about 48 ft at MLLW, is more than 20 ft deeper than the controlling depths on either side of Knik Arm Shoal (25 ft at MLLW). The navigation aids in the area now guide incoming ships along the Point MacKenzie Range north of the crest of Knik Arm Shoal. Departing ships are guided along the Fire Island Range south of the crest. Figure B-3 shows 1992 conditions superimposed on contours printed on chart 16665 (NOAA 1990). The Point MacKenzie range appears to be on the verge of massive encroachment from North Point Shoal, and any improvement along this alignment would require much more excavation than an improvement along the Fire Island Range. The Fire Island Range appears to fall along a scouring trend, even though Woronzof Shoal has expanded northward in its direction.

The interpretation of trends from figure B-3 is complicated by differences in the accuracy and completeness of hydrographic data and in analytical methods applied to derive contours from randomly spaced soundings. The 1992 data were supplied by the NOAA ship *Rainier*, corrected only for predicted tides. Detailed investigation of some sounding lines indicates that later correction with measured tides may change substantial numbers of soundings by several feet. The contouring method applied with 1992 data smoothed adjacent soundings to an average value, with a view toward distinction of trends. Both the 1982 bathymetry (chart 16665, NOAA 1990) and the 1992 soundings provided by the *Rainier* independently led to the Fire Island range as the optimum center line for a channel improvement.

2.3 Channel Dimensions

2.3.1 <u>Channel Width</u>. Passing traffic of deep draft vessels is rare in Knik Arm and is generally avoided by pilots. The year 1991 saw 450 visits at the Port of Anchorage, including essentially all the deep draft traffic in Knik Arm. Container-ship arrivals and departures are scheduled by two liner services; both arrivals and departures often fall on the same day. Pilots of these ships avoid passing until they are beyond Fire Island Shoal. Fire Island Shoal is less than 30 minutes steaming from the Port of Anchorage, so shippers have never felt that passing in constricted areas was worth the added risk of collision or grounding. A channel designed for one-way traffic would not measurably impede deep draft vessels projected for the foreseeable future.

The key parameters for channel width design are vessel length and beam, navigation accuracy, crosscurrents, crosswinds, and, in the case of Knik Arm, the effects of ice on ship control. A conservative application of these parameters was followed, generally as presented by PIANC (1980) and EM 1110-2-1613 (USACE 1983). The channel is viewed as having a central sweep path, over which any part of the ship may pass under normal conditions. Width is added on each side for a wider sweep path under extreme conditions. A further addition of symmetric bank clearances (safety margins) defines the bottom width of the channel.

The normal sweep path must consider the accuracy of the ship's position with a view toward the effectiveness of the aids-to-navigation system. The strength of crosscurrents must also be considered, since these may result in significant yaw or meandering about the desired path. Visual positioning by the ranges at Knik Arm Shoal is usually accurate to within 200 ft. Subsection 4.3.1 in the Main Report discusses potential improvements which could result in positioning accuracy to within several meters.

Crosscurrent components along the proposed channel alignment in the 4-knot surface extremes at Knik Arm Shoal probably never exceed 2 knots. PIANC (1980) proposes a cross-current channel width allowance, W_c, of:

$$W_c = \frac{L}{2} * \sin(\tan^{-1}(\frac{u_y}{V_s})) ,$$

where L is the vessel length, u_y is the cross-current speed, and V_s is the vessel speed. Applying L = 800 ft, u_y = 2 knots, and V_s = 15 knots, the computed cross-current channel width allowance, W_c = 53 ft. A cross-current of 3 knots leads to W_c = 78 ft. Based on these considerations, a normal sweep path of 3 times the beam appears quite conservative.

Extreme conditions at Knik Arm involve ice forces, strong cross-channel winds from Turnagain Arm, low visibility or darkness, and the lack of channel buoys in winter. No objective approach to combine these factors is suggested in available technical guidance. An additional 50 percent sweep path width, or 4.5 times the beam, is allowed for a combination of these extreme conditions.

Bank clearance allowances usually range from B/2 to 1.5B. An extreme value of 1.5B on each side is chosen, to account in part for hard bottom conditions and infrequent hydrographic surveys. The total channel width is then 7.5 times the vessel beam, rounded to 800 ft. This width notably exceeds the length of any vessel listed in table B-1. Shippers and pilots were consulted and independently stated preferences for channel widths from 800 to 1,000 ft (see Totem Ocean Trailer Express, memo dated November 2, 1992, appendix E).

Uncertainties in prediction of shoaling rates, discussed in more detail below, led to an additional allowance in channel width to postpone maintenance dredging. The distributed cost of biennial dredging is less than half the cost of annual dredging, calculated by cash flow discounting. Deepening channels below the depth objectively determined to be adequate for navigation safety to postpone maintenance dredging is a well-accepted measure to reduce long-term project costs (*e.g.*, Trawle 1981). This approach is applied here to account for the prospect of encroachment of excess bed load into the channel margins. An additional 100 ft on each side is proposed for advance maintenance, leading to a total excavated width of 1,000 ft. Figure B-37 illustrates the channel width rationale. Figure B-3 shows the limits of a 1,000-ft-wide channel, centered on the existing Fire Island navigation range.

2.3.2 Channel Depth. The elevation of the channel depth is determined in the case of Knik Arm Shoal by economic criteria in the form of savings in transportation costs. These cost savings are due to savings in transit time for ships approaching and departing the Port of Anchorage. Appendix D describes the numerical simulations of vessel transits of Cook Inlet which were used to determine the time savings achievable by channels of varying depth, with reference to actual arrivals at the port in 1991. The simulations apply a fixed gross keel clearance of 10 ft above the shallowest points of the channel. Ship owners and Cook Inlet pilots advised that their practice is to wait for 8 to 10 ft of gross keel clearance across the hard bottom at Knik Arm Shoal. Figure B-38 illustrates the increments of gross keel clearance and its relation to excavation depth.

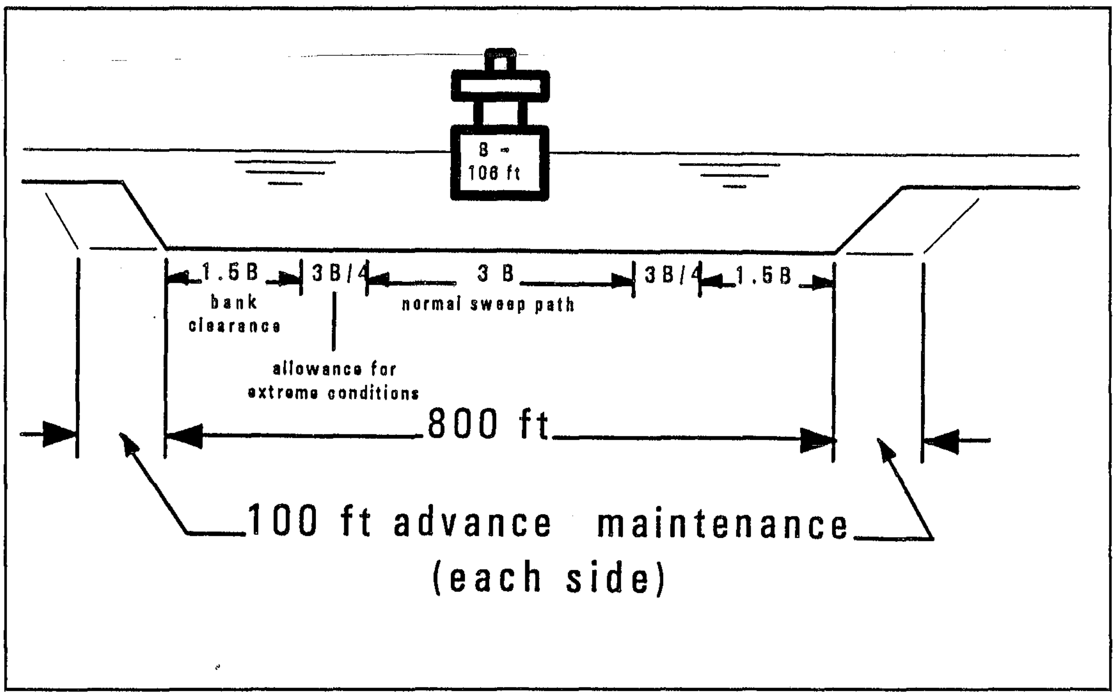

FIGURE B-37.--Channel width rationale.

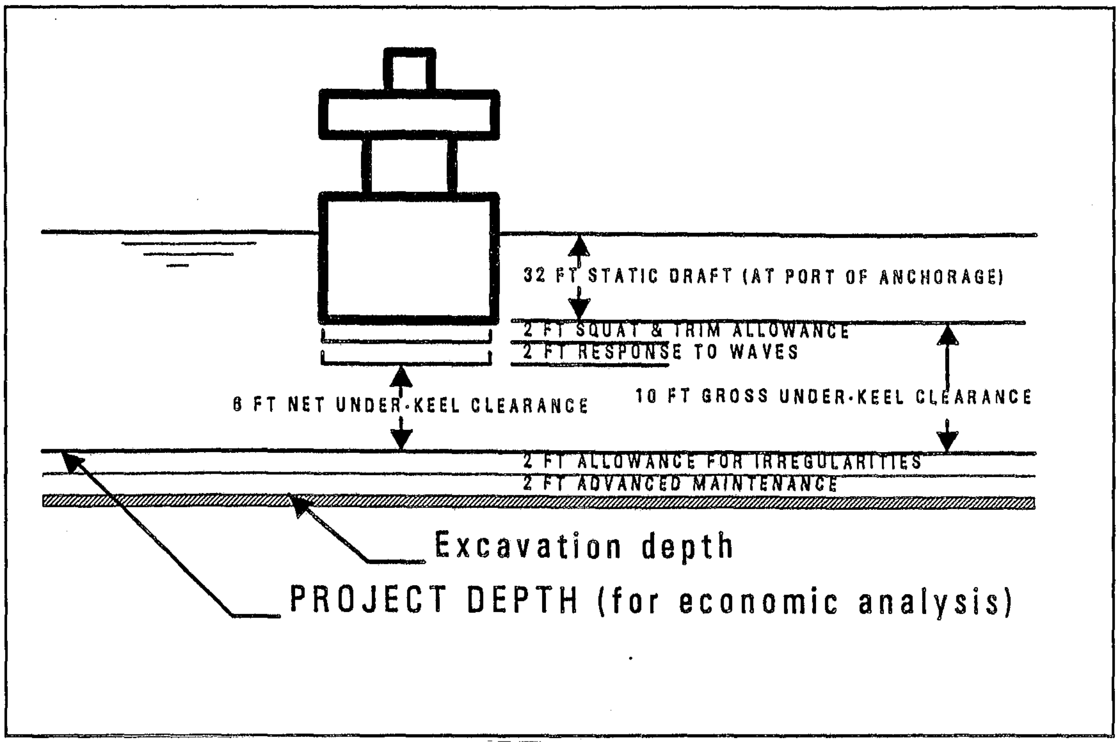

FIGURE B-38.--Channel depth rationale.

A static draft of 32 ft in Knik Arm conditions is assumed. This draft accounts for the reduced buoyancy of vessels in the brackish water of Knik Arm and for any trim imbalance, *i.e.*, fore-and-aft differences in draft due to the distribution of weight aboard. Vessels underway draw down into the water as a result of hydrodynamic pressure gradients caused by their motion through the water. This phenomena, known as "squat," varies with vessel speed, water depth beneath the keel, and the ratio of the vessel cross-section area to the cross-section area of the channel. Figure 5-3 of Engineer Manual (EM) 1110-2-1613 (USACE 1983) offers a graphical solution of relevant hydraulic formulas. Applying a channel width of 1,000 ft, water depth of 42 ft, vessel beam of 106 ft, vessel draft of 32 ft, and vessel speed of 10 knots, a squat of 1.7 ft is predicted. The formulas do not offer reliable solutions for speeds higher than about 14 knots, at which a squat of about 4.2 ft is predicted.

PIANC (1980) reports that physical model tests on a 250,000-deadweight-ton tanker showed squat ranging from a few inches to around 2 ft in a speed range of 2 to 8 knots in a restricted channel, less than theoretical predictions. A squat allowance of 2 ft for this design is assumed at slower speeds during rough seas, and 4 ft is assumed at higher speeds during calm seas. Vessel response to waves is minimal at Knik Arm Shoal, because depth and fetch limitations preclude any but short period waves of less than about 5 ft in height. The response of deep draft vessels to such waves is small, but an extreme value of 2 ft of heave (up and down motion) is assumed. The sum of ship-related factors, in either calm or rough seas, is thus 4 ft. EM 1110-2-1613 (USACE

1983) suggests a minimum net under-keel clearance of 3 ft for hard bottom conditions. The uncertainties in the static draft, trim, squat, and response to waves are considered as the cause to double this safety margin to a total of 6 ft, which yields a gross keel clearance of 10 ft, in keeping with pilots' actual practice.

Excavation depth, as presented in directions to a dredge operator, must allow for the uncertainties in vertical control of the dredge. Dredging accuracy is verified by acoustic soundings. Modern acoustic soundings are accurate to within a few tenths of a foot, but averaging of adjacent soundings to digitize analog fathometer signals results in a practical accuracy on the order of 1 ft. This accuracy, combined with the tendency of a sandy bottom to pile up in transient bedforms (ripples and dunes) calls for an additional 1-ft allowance. Directions to dredgers would therefore be to excavate at least 2 ft below the depth reported to shippers.

The prospect of frequent dredging is serious in Cook Inlet, as shown by the annual maintenance dredging requirement at the Port of Anchorage. The conditions at Knik Arm Shoal appear to be quite different; the settlement of silt, as occurs at the port, does not appear likely. Excess bed-load transport across the channel, either from the flanks of Knik Arm Shoal itself or from eventual encroachment by Woronzof Shoal, is a more likely mode of shoaling. The rate at which this might occur is difficult to predict with present knowledge. An additional excavation depth increment of 2 ft is applied to postpone maintenance dredging to an interval of 2 years or greater. This additional allowance would give the channel a level capacity between -39 ft and -35 ft MLLW of about 74,000 cubic yards for every 1,000 ft of reach. This capacity, combined with the extra 100 ft on each side of the channel, appears adequate to preclude annual maintenance dredging. Predictions for maintenance dredging quantities and intervals are discussed in more detail later in this appendix.

2.3.3 Channel Design Summary. A channel width of 800 ft has been determined to be adequate for one-way traffic in the worst Knik Arm Shoal conditions. An extra 200 ft excavation width (1,000 ft total) would prevent the need for annual maintenance dredging. A depth of 32 ft plus 10 ft gross keel clearance (42 ft total) is adequate for safe passage over the channel bottom. Simulations of ship transits at various depths indicate that a channel with a charted bottom elevation of -35 ft MLLW is near optimum in terms of ship transit time savings. Allowances for dredging and sounding uncertainties and 2 ft advance maintenance call for excavation to the -39 ft MLLW elevation.

2.4 Dredged Material Disposal Site

Figures B-2 and B-3 indicate an area 70 to 80 ft deep at low tide, just to the north of North Point on Fire Island and south of the Point Woronzof navigation range. This site is deep enough for disposal of the quantities to be excavated without significant impact on navigation or the overall hydraulics of the area. Currents in the area are consistently strong; these currents would rapidly disperse plumes of dredged material. Measurements at other sites (*e.g.* Kraus 1991), together with the experience of monitoring one dredged material plume in waters of the same depth off the Port of Anchorage, indicate that a plume would be undetectable at this site within 10 minutes or less after discharge. The material to be disposed would be the same as natural bottom materials at the disposal site. Fire Island protects the area from occasional severe winds out of Turnagain Arm; this protection would prevent complications in discharge operations. The site is near the marked shipping route, but safe passage past the disposal site is available over a distance of about 3,000 ft. Figure 4-4 in the Main Report shows the relationship of the proposed channel to the disposal area.

Sites northeast of Knik Arm Shoal, toward the Port of Anchorage, are not considered suitable because of the presence of 10 power cables owned by Chugach Electric Corporation. These cables run from Point Woronzof to Point MacKenzie through a corridor that is about a mile wide at the center of the crossing. The corridor marked on nautical chart 16665 (NOAA 1990) reaches within one-half mile of the proposed channel excavations at its westernmost point. The cables would have to be located carefully before any excavation is accomplished. Passage of excavation equipment or disposal equipment over the cable area would be minimized, and no excavation or disposal would be conducted within the cable area. The next closest suitable open-water disposal site is beyond Fire Island Shoal, with full exposure to Turnagain Arm winds and waves from upper Cook Inlet.

The sand and gravel to be dredged is valuable for use in foundations of buildings and roads in the Anchorage area. Disposal of this material ashore, however, would significantly complicate disposal operations and raise their cost. Onshore disposal is physically possible, but the added expense would be substantial and could not be paid by the Federal Government. The added expense could be paid by another party, however, given approval of the local sponsor and all concerned resource and permitting agencies.

The North Point open-water disposal site appears optimum for dredged material disposal at this time, but other options may yet be considered in the feasibility study to follow.

3. EXCAVATION QUANTITY AND COST ESTIMATES

3.1 Excavation Quantity

The digital data provided by the NOAA ship *Rainier* from the 1992 hydrographic survey of the Knik Arm Shoal area were applied to estimate excavation quantities. These data were corrected for predicted tides, and some uncertainty in these corrections is evident on close inspection of individual soundings. Launches from the *Rainier* criss-crossed the area again and again over a period of weeks. Individual sounding lines are apparent in figure B-39, which shows the pattern of more than 37,000 soundings in the area shown. Some adjacent parallel sounding lines showed systematic differences, imparting a wavy appearance to the bottom. The wavy appearance cannot be rationally attributed to bedforms because of an excessive wavelength of over 150 ft and the consistent alignment with the sounding lines. Dunes in this area should propagate downstream, or in other words, the dune crests should be aligned across the tidal currents. Most sounding lines were also across the natural channel alignment and direction of tidal flow, but some were not, and the waviness follows the sounding lines in these areas as well. Discussions with NOAA hydrographic specialists indicate that these uncertainties will eventually be corrected when measured water levels are applied to correct for tidal fluctuations. This will not occur within the schedule of this reconnaissance study. The errors are probably symmetrical, and excavation quantities computed over several sounding lines should be very near the actual quantity for that reach.

Figure B-40 shows an aerial perspective view of the area to be excavated, as if a hypothetical 1,000-ft-wide plane were passed through the flank of the shoal at an elevation of -39 ft MLLW. Figure B-4 shows a cross section along the channel center line. Side-slopes of 1 part vertical to 3 parts horizontal (outward) were applied in automated computation of the excavation quantity of 353,000 cubic yards. Selected cross-section areas were computed by other means, and a rough hand computation of the overall quantity was also completed. Both confirmed that the automated computations are correct.

3.2 Cost Estimate

The nature of the excavated material, the excavation quantity, conditions at the excavation site, and the relation of the excavation site to the prospective disposal site were of primary concern in estimating the means and related costs for accomplishing the work. A hopper dredge was used to excavate 1.1 million cubic yards from Knik Arm Shoal in 1975. The coarse material proved difficult for the Corps of Engineers hopper dredge *Biddle,* and down time for maintenance was unusually high. Hopper dredges are the best choice for large-quantity dredging projects, roughly those exceeding 1 million cubic yards.

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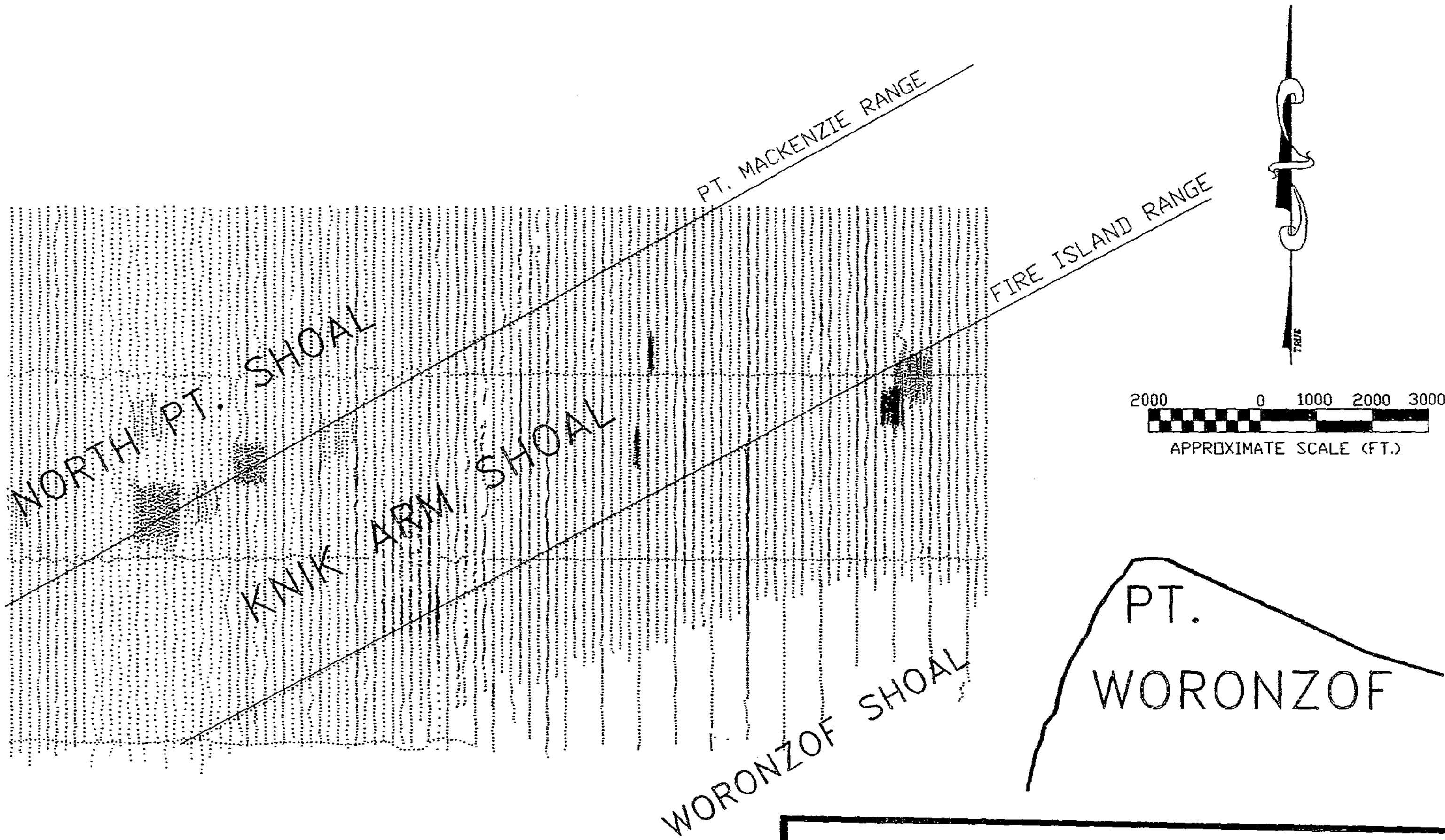


PATTERN OF NOAA SOUNDINGS, 1992

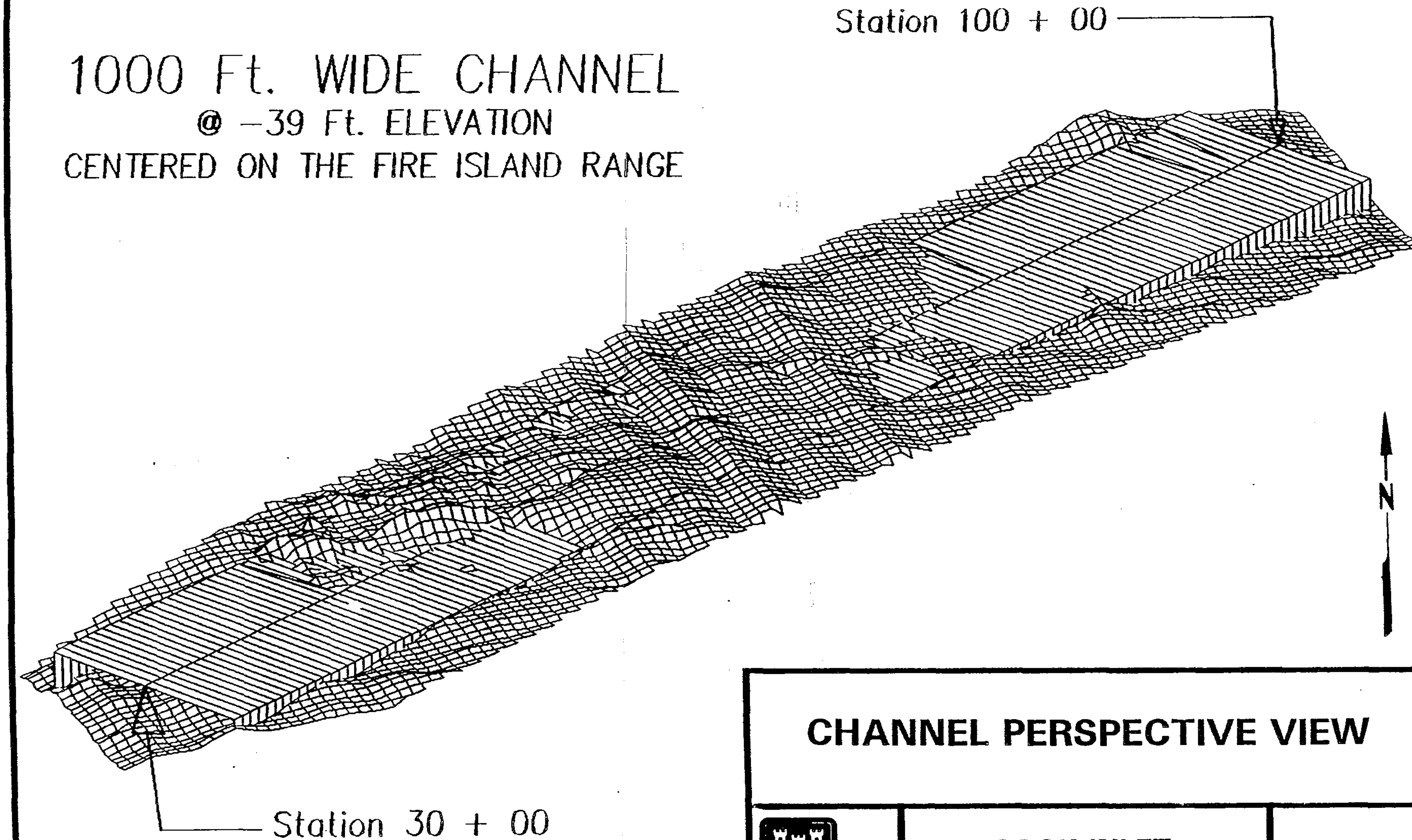
US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

B-39

125656

1000 Ft. WIDE CHANNEL
@ −39 Ft. ELEVATION
CENTERED ON THE FIRE ISLAND RANGE



CHANNEL PERSPECTIVE VIEW		
US Army Corps of Engineers Alaska District	**COOK INLET** **NAVIGATION**	**B-40**

The proposed excavation of 350,000 cubic yards will be most efficiently accomplished with mechanical equipment in conjunction with annual maintenance of the Port of Anchorage maneuvering area. A barge-mounted crane rigged with a clamshell bucket with a capacity of 4 cubic yards or more is the most common choice of contractors for the port dredging project, which averages about 220,000 cubic yards each year. The Corps of Engineers hopper dredge *Essayons* has twice accomplished the port dredging, but with some difficulty in the corners and near ships moored at the dock. A clamshell dredge has less difficulty with constricted areas, and its hourly costs are less during standby.

Contractors would probably choose a larger bucket, perhaps as much as 15 cubic yards capacity, for Knik Arm Shoal excavations. A larger bucket would deliver a faster excavation rate and allow completion of the combined projects in a shorter time. It would be more efficient at removal of large boulders and consolidated glacial deposits which could be encountered in the initial excavation. The currents are stronger at Knik Arm Shoal than at the port, and the weight of a larger bucket would help keep the desired vertical wire angle for maximum control. Stronger currents and the prospect of concurrent strong winds would require a more powerful tugboat for slow-speed maneuvering of a hopper barge from alongside the dredge to the disposal area off Fire Island. These conditions would also warrant more anchors for the dredge than typically used at the port. These practical requirements for Knik Arm Shoal would not hinder dredging at the Port of Anchorage with the same equipment. The equipment used at Knik Arm Shoal would be perfectly suitable for maintenance dredging at the Port of Anchorage. Mobilization and demobilization costs are therefore considered expenses of the maintenance dredging project at the Port of Anchorage and not of the Knik Arm Shoal dredging project.

Table B-2 summarizes the cost estimate for initial dredging of the proposed channel, with the assumptions and considerations stated above. Maintenance dredging of the channel would also be combined with Port of Anchorage maintenance dredging. The dredged material would be exclusively sand, and production rates would be somewhat steadier, but no significant changes in unit costs are anticipated after initial dredging. The estimated cost of mobilization and demobilization (mob/demob) is included in Table B-2, but this cost is not included in computations of net benefits of the potential dredging project or its benefit-cost ratio.

TABLE B-2.--*Estimated cost of initial dredging*

Increment	Estimated quantity	Unit	Unit price[a]	Contract cost	Cost with S&A[b] and full contingencies[c]
Mob/demob	1	Job	Lump sum	$234,826	$280,000
Dredging	353,000	yd^3	4.52	$1,910,436	2,280,000[d]
			TOTAL		**$2,560,000**

[a] Unit price includes a 20% preliminary design contingency.

[b] S&A = supervision and administration.

[c] An additional 19.35% is applied, including 10% management reserve contingency and compounded S&A cost at 8.5%.

[d] The cost applied in feasibility considerations is $2,280,000 + $16,000 (interest during construction) = **$2,296,000.**

4. MAINTENANCE DREDGING REQUIREMENTS

4.1 Sediment Transport at Knik Arm Shoal

4.1.1 Sediments. Table B-3 shows characteristics of 10 bed samples taken in July 1992 on or near the proposed channel alignment. This summary corresponds to the detailed test results presented in the supplement to this appendix. Most of the bed in the area is relatively uniform medium sand (0.42 mm < D_{50} < 2.0 mm). The coarsest of the samples described in table B-3 (sample 6427) was collected off Point Woronzof, beyond the limits of the proposed excavation, in an area about 60 ft deep at MLLW. The next coarsest was collected near the crest of Knik Arm Shoal, north of the excavation limits. A representative D_{50} = 0.43 mm is applied in the following sediment transport computations, assuming a specific weight of 2.65 for silicate sand.

TABLE B-3.--*Selected bed sample characteristics*

Sample number	D_{85} (mm)	D_{50} (mm)	D_{15} (mm)
6437	0.55	0.42	0.31
6436	0.59	0.44	0.33
6435	4.63	0.50	0.30
6428	0.54	0.41	0.32
6427	35.7	30.3	14.2
6115	0.54	0.40	0.27
18-8	0.57	0.43	0.33
18-7	0.57	0.43	0.33
18-6	0.55	0.41	0.30
S-9	1.76	0.54	0.33

4.1.2 Water Properties. Water densities varied between sigma-t of 6 and 9. A representative density of 1008 kg/m^3 (sigma-t = 8) is applied below, corresponding to a specific weight of S_w = 1.008. The corresponding dynamic viscosity, μ, (at 40° F) is 0.002 kg/m-s and the kinematic viscosity, ν, is 1.536 x 10^{-6} m^2/s.

4.1.3 Currents. Vertical averages of current profiles measured in July 1992 by ADCP were 3 to 3.5 knots at mid-tide on both the flood and the ebb. Maximum current speeds just over 4 knots were measured in some profiles near the surface. The tidal ranges were moderate during the ADCP measurements, but a vertical average current speed of 3.5 knots (1.8 m/s) is assumed to be representative of mid-tide conditions in the proposed channel alignment. The depth at mid-tide in the proposed channel will be about 48 ft (14.5 m).

4.1.4 Sediment Transport Parameters. Parameters of sediment transport are computed from the following assumptions, generally in keeping with formulations summarized in Vanoni (1975). The Froude Number, F, is the ratio of inertial forces to those of gravity,

$$F = \frac{U}{\sqrt{gh}} = 0.15 ,$$

where U is the vertically averaged current, g is the acceleration of gravity (32.2 ft/s^2 or 9.81 m/s^2), and h is the water depth. Since F is less than 1, the flow is subcritical and the bedforms anticipated are dunes propagating downstream. The bed-related Reynolds Number, the ratio between inertial and frictional forces, is

$$R = \frac{U_s * D_{50}}{\nu} .$$

The shear velocity, representing the water speed in the bottom boundary layer, is

$$U_s = \sqrt{\frac{f}{8}} .$$

Shear velocity is a function of the Darcy-Weisbach bed friction factor, which for 10 < R < 500 is

$$f = 0.017 * \exp \frac{R^{-0.18}}{7.04 - 7.5 * R^{-0.18}} .$$

The friction factor is, in turn, a function of Reynolds Number; therefore an iterative solution is required. A shear velocity of U_s = 0.12 m/s, a friction factor of 0.036, and Reynolds Number of R = 33.6 yield a consistent solution. Bottom shear stress is then

$$\tau_o = \rho_w * U_s^2 = 14.6\ N/m^2 .$$

4.1.5 Sediment Transport Capacity. The Shield's curve provides a well-accepted means of determining whether or not the bed is in motion, *i.e.*, whether hydraulic forces are sufficient to move the bed material. The critical shear stress for sediment motion in the range 10 < R < 500 is

$$\tau_c = 0.02 * R^{0.176} * D_{50} * (\gamma_s - \gamma_w) = 0.257 \ N/m^2 \ ,$$

where γ_s and γ_w are the specific gravities of the sediment and the ambient water (γ = gS). The critical stress for sediment motion (τ_c = 0.257 N/m^2) is substantially less than the estimated mid-tide bottom shear stress (τ_o = 14.6 N/m2). In a corresponding manner, the critical shear velocity

$$U_c = \frac{1}{\sqrt{f}} * \sqrt{\frac{\tau_c}{\rho_w}} = 0.08 \ m/s,$$

is substantially less than the computed shear velocity (U_s = 0.12 m/s), so sediment motion can be expected throughout most of the tidal cycle. The largest grain size which will be in motion can be estimated by trial-and-error solution of the above formulas until the computed bed characteristics with increased grain size match the critical parameters. A grain size of about 1 cm (small gravel) has a Reynolds Number, R = 621, a friction factor, f = 0.0225 (constant for R > 500), a bottom shear stress, τ_o = 0.009 N/m^2, and a critical shear stress, τ_c = 0.009 N/m^2. Smaller sediment can be expected to be in motion for some portion of each tidal cycle, and larger sediment usually will not be in motion. This is in keeping with the 1975 experience of the dredge *Biddle*, which excavated large quantities of pea gravel of about this size from the area of the proposed channel alignment.

Gross sediment transport can be estimated by the formulation of Engelund-Hansen, which is generally suitable for conditions where R > 12, D > 0.15 mm, bed slope is variable, and dunes occur. The gross transport rate per unit width of channel is given by

$$q = 0.05 * U^2 * \sqrt{\frac{D_{50}}{g*(\frac{\gamma_s}{\gamma_w}-1)}} * [\frac{\tau_o}{(\gamma_s-\gamma_o)*D_{50}}]^{3/2} = 0.003 \ m^3/s\text{-}m$$

The gross transport over 1,000 ft would thus be 0.785 m^3/s at mid-tide, which would decrease to near zero at slack water, then gradually rise to about the same rate in the opposite direction at the next mid-tide. Any net transport in one direction would thus be due to differences in flood and ebb currents. Net transport, in this case, would not necessarily lead to accumulation in the channel. The deeper water at each end of the channel has tremendous capacity to accept net transport, so sediment transport along the primary direction of tidal flow (*i.e.*, the channel alignment) would not be the most likely source of shoaling in the channel. Some long term accumulation from crosscurrents associated with conditions beyond the margins of the channel appears a more likely cause of shoaling by bed-load transport.

4.1.6 Sedimentation. The likelihood of settlement of particles suspended in the water column over the channel can be evaluated by comparison of the particle settling velocity to the range of vertical currents known to be common in the area. A spherical particle will settle in a still ideal fluid at a downward velocity, V_f, of

$$V_f = \sqrt{\frac{4}{3} * \frac{D_{50}}{C_d} * (S_s - S_w)} ,$$

where S_s and S_w are the specific weights of the sediment and water. The drag coefficient, C_d, is

$$C_d = \frac{24}{R} .$$

The Reynolds Number is here defined as

$$R = \frac{V_f * D_{50}}{\nu} ,$$

so an iterative solution for V_f is required. Knik Arm Shoal sand (D_{50} = 0.43 mm) has an ideal fall velocity of about 1 cm/s (0.02 knots) by this formulation. This is 2 orders of magnitude smaller than the average mid-tide current, indicating that turbulence in the channel is capable of keeping this sand and any smaller particles in suspension throughout most of the tidal cycle. Silt-sized particles are not likely to accumulate anywhere on the bottom in these conditions.

4.2 Maintenance Dredging - Alternate Scenarios

The maintenance dredging schedule for the proposed Knik Arm Shoal channel is difficult to predict because of the high tidal energy and complex hydrography and hydrographic history of the surrounding waterway. Analyses of hydrographic change in the area show massive migrations of shoals. The chart data are 10 years or more apart in time, so these analyses do not resolve changes which may be significant on a tidal (monthly), seasonal, or annual time scale. The comparison of printed charts with more extensive shipboard survey data is uncertain. It is clear, however, that large shifts of shoals with potential to affect the proposed channel have occurred in the past on a time scale of 10 years or less.

Extensive measurements were made in July 1992 of the bathymetry, bed material, water properties, and currents at the project site. Fine material is heavily concentrated in the water column, but does not appear to settle permanently on the bottom anywhere near Knik Arm Shoal. Sediment transport in the area is bed-load transport of the prevailing sand. Vertically averaged tidal flows are 3 to 3.5 knots on both the flood and the ebb. Depths along the proposed channel alignment vary twice daily from 35 ft at low tide (project depth) to more than 60 ft at high tide. Dunes 1 m high or more are possible in these conditions.

The following scenarios of channel maintenance take into account the mode of transport and the potential source of excess sediment supply to the channel. They refer to a channel 1,000 ft wide and centered on the existing Fire Island navigation range. Frequencies and quantities of dredging can be applied with equal confidence to a channel 800 ft wide on the same alignment. Frequencies of maintenance dredging are generally related to historical rates of migration of large-scale hydrographic features in upper Cook Inlet, in particular changes of Knik Arm Shoal, Woronzof Shoal to the south, and North Point Shoal to the north. All scenarios include annual hydrographic surveys and testing of bed samples, estimated to cost $30,000 each year, unless otherwise noted.

4.2.1 Future A - Continual Scour (Most Optimistic). Tidal currents are concentrated by North Point Shoal, Knik Arm Shoal, and Woronzof Shoal to the south of Knik Arm Shoal, along the proposed channel alignment. This focus of tidal energy and the presence of significantly deeper areas immediately upstream and downstream allow the channel to continually transport any gross infill from its margins along the channel into deeper water. No maintenance dredging is required. A yet more optimistic variation of this scenario would be to leave surveys of the channel to NOAA on a 5-year cycle after the first 10 years (Corps survey costs dropped). This scenario, for risk analysis, is considered to have an annual probability of at least 10 percent.

4.2.2 Future B - Infill From Eastern Flank of Knik Arm Shoal. This scenario involves the adverse effect of crosscurrents diverted by the crest of Knik Arm Shoal. Though small in comparison to the nearly rectilinear tidal currents in the channel, these crosscurrents bring material into the channel from the eastern side of Knik Arm Shoal. An excess supply exists in some years in the 1,000-ft reach from Station 70 to Station 80 (figure B-3). Surveys in year 3 reveal that the channel bed has risen to -37 ft MLLW over half of the channel. Dredging is first accomplished in year 4, excavating 30,000 cubic yards from the channel. The mobilization and demobilization (mob and demob) cost is shared with the annual maintenance dredging of the Port of Anchorage. This cycle repeats, on the average, every 4 years throughout the project life. The following graph illustrates the frequency of dredging episodes, "D," on a time line of 50 years.

```
Year      1   5    10   15   20   25   30   35   40   45   50
          ----+----*----+----*----+----*----+----*----+----*
Dredging     D   D   D   D   D   D   D   D   D   D   D   D
```

The dredging cost of each episode for 30,000 cubic yards at $5.42 per cubic yard is $162,600, not including mob and demob. Doubling the quantity would double the cost per episode. Doubling the frequency (dredging every other year) would more than double the equivalent annual cost. Doubling the frequency and the quantity would more than quadruple the equivalent annual cost.

4.2.3 Future C - Infill From an Extension of Woronzof Shoal. An extension of Woronzof Shoal advances into the channel from the south, along the 1,000-ft reach between sta 60 and sta 70 (see figure B-3). The shoal extension advances toward the channel at an average rate of 100 ft per year. The -35 ft-MLLW contour was about 1,000 ft from the channel boundary in July 1992. The first encroachment on the channel is detected in year 10. Maintenance dredging is first accomplished in year 11 with removal of 30,000 cubic yards for $162,600, not including mob and demob. This is repeated at the same rate and cost annually for 10 years. The extension begins a retreat cycle in year 20 and does not encroach upon the channel again until year 40. Annual dredging is necessary again in years 41 through 50. The cycle of dredging requirements for this alternative is illustrated in the following graph, with a "D" signifying each maintenance dredging episode.

```
Year        1   5    10   15   20   25   30   35   40   45   50
            ----+----*----+----*----+----*----+----*----+----*
Dredging             DDDDDDDDDD                     DDDDDDDDDD
```

Doubling the quantity would double the cost. Doubling the frequency, *i.e.*, first dredging in year 5, followed by 5 years of annual dredging, followed by 10 years without dredging, and so on, would more than double the cost. The combination of these two sensitivity tests would more than quadruple the cost.

4.2.4 Future D - Massive Migration of Woronzof Shoal (Most Pessimistic). Woronzof Shoal expands northward from 1992 at a rate of 200 ft per year, first encroaching on the channel in the year of initial excavation (1998). The initial dredging quantity is increased by about 60,000 cubic yards (yd^3), on a similar scale as encroachments predicted above. A steady growth northward increases the encroachment until the -35-ft-MLLW contour of Woronzof Shoal intersects that of Knik Arm Shoal. This major constriction of Knik Arm from the south is accompanied by scour along the north flank of Knik Arm Shoal. Annual maintenance dredging is required, with quantities increasing by 50 percent each year as Woronzof Shoal increases its northward expansion.

The maintenance quantity exceeds the initial dredging quantity in year 5, at which time a new channel alignment is considered. Hopper dredging is adopted when the quantity exceeds 400,000 yd^3 in year 5, which adds a mob and demob cost of $0.5 million, but reduces the unit price to $2.50 per cubic yard. Studies are accomplished at $100,000 per year in years 6 and 7. The channel alignment is shifted to the (now scoured) Point MacKenzie Range. Initial excavation is similar to that now estimated for alignment along the Fire Island Range. The old channel alignment is abandoned in year 8, when the Point MacKenzie Range is first excavated. Maintenance dredging of the new alignment is not required for 20 years (until year 28), when an equivalent expansion southward of North Point Shoal first encroaches on the north of the channel. The channel alignment is switched again, back to the Fire Island Range, in year 34. No maintenance is required for the remainder of the first 50 years of the project. The following graph illustrates the sequence of dredging episodes, "D," in this alternative future. Table B-4 shows the estimated costs. Doubled quantities and frequencies would have similar effects on costs as other alternatives. This alternative is considered to have less than a 10-percent annual probability of being exceeded.

```
Year      1   5    10   15   20   25   30   35   40   45   50
          ----+----*----+----*----+----*----+----*----+----*
Dredging  DDDDDDDD                    DDDDDDD
```

TABLE B-4.--*Estimated costs for alternative future D*

Year	Dredging quantity (yd^3)	Cost ($)
0	353,000	2,172,000
1	90,000	768,000
2	135,000	1,012,000
3	202,500	1,375,000
4	303,750	1,928,000
5	455,600	1,640,000
6	683,400	2,210,000 + 100,000 (study)
7	1,025,200	3,065,000 + 100,000 (study)
8	353,000	2,560,000
.		
.		
28	90,000	768,000
.		(as above, through year 34)

4.2.5 <u>Expected Maintenance Dredging Requirements</u>. These scenarios include all the apparent sources of excess sediment transport and the modes of encroachment which site conditions indicate as physically possible. These four scenarios are deemed to be roughly symmetrical in terms of their relative likelihoods. The expected maintenance should thus be somewhere between futures B and C. A conservative outlook, which accounts for the advance maintenance dredging planned in both width and depth, is thus to plan for maintenance dredging of material every other year from Knik Arm Shoal's eastern flank, from an extension of Woronzof Shoal, or from both sources of excess sediment transport. The maintenance dredging requirements for evaluation of economic feasibility involve an allowance for channel slope sloughing during the first 4 years. Dredging quantities during the second and fourth years are estimated to be 80,000 cubic yards; the quantity is estimated at 60,000 cubic yards every other year thereafter. This intermediate future appears to be the most reasonable "expected" or "weighted average" prospect to specialists who have studied the site conditions. The associated maintenance dredging costs are estimated to be $433,600 in years 2 and 4 and $325,000 every other year thereafter.

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SUPPLEMENT
TO APPENDIX B, ENGINEERING

Selected Test Results
For Upper Cook Inlet Bottom Samples

* * * CORPS OF ENGINEERS - NORTH PACIFIC DIVISION LABORATORY * * *
COOK INLET (92-S-269)
Boring: -- Sample: S-9 Depth: 17.0 M Lab No.: 26903

------ Sieve Analysis ------

No hydrometer analysis.

Sieve	Cumulative Grams Retained	Percent Passing
3 In.	0.00	100.0
2 In.	0.00	100.0
1.5 In.	0.00	100.0
1 In.	0.00	100.0
3/4 In.	19.60	97.0
1/2 In.	34.70	94.7
3/8 In.	40.70	93.7
No. 4	57.30	91.2
No. 10	92.20	85.8
Pan	649.00	0.0
No. 16	6.10	80.1
No. 30	31.90	56.2
No. 50	84.30	7.6
No. 100	86.10	5.9
No. 200	87.50	4.6
Pan	92.50	0.0

D85: 1.76 D60: 0.64 D50: 0.54 D30: 0.42 D15: 0.33 D10: 0.31 mm
Cu: 2.07 Cc: 0.88

Liquid Limit: NP Plasticity Index: NP
Fines Type Used for Classification: ML, SILT

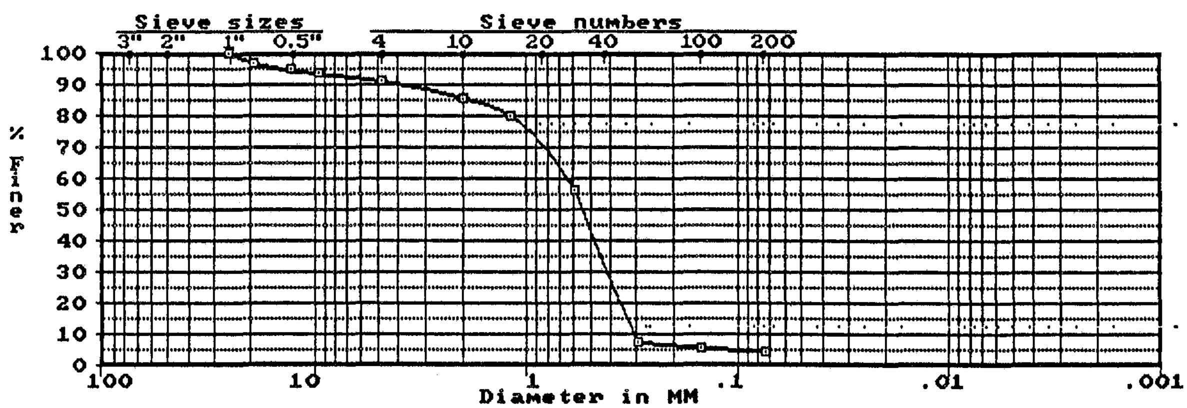
Gravel: 8.8% Sand: 86.6% Fines: 4.6%

------------------------- ASTM D 2487 Classification -------------------------

SP Poorly graded SAND

---------------------------------- Comments ----------------------------------

Percent finer than 0.02 mm unknown, therefore no frost classification.



* * * CORPS OF ENGINEERS - NORTH PACIFIC DIVISION LABORATORY * * *
COOK INLET (92-S-269)
Boring: -- Sample: 18-6 Depth: 15.5 M Lab No.: 26909

------ Sieve Analysis ------

No hydrometer analysis.

Sieve	Cumulative Grams Retained	Percent Passing
3 In.	0.00	100.0
2 In.	0.00	100.0
1.5 In.	0.00	100.0
1 In.	0.00	100.0
3/4 In.	0.00	100.0
1/2 In.	0.00	100.0
3/8 In.	0.00	100.0
No. 4	0.00	100.0
No. 10	2.70	99.5
Pan	532.40	0.0
No. 16	0.60	98.8
No. 30	5.10	94.0
No. 50	81.30	12.2
No. 100	87.40	5.7
No. 200	88.90	4.1
Pan	92.70	0.0

D85: 0.55 D60: 0.44 D50: 0.41 D30: 0.34 D15: 0.30 D10: 0.24 mm
Cu: 1.88 Cc: 1.14

Liquid Limit: NP Plasticity Index: NP
Fines Type Used for Classification: ML, SILT

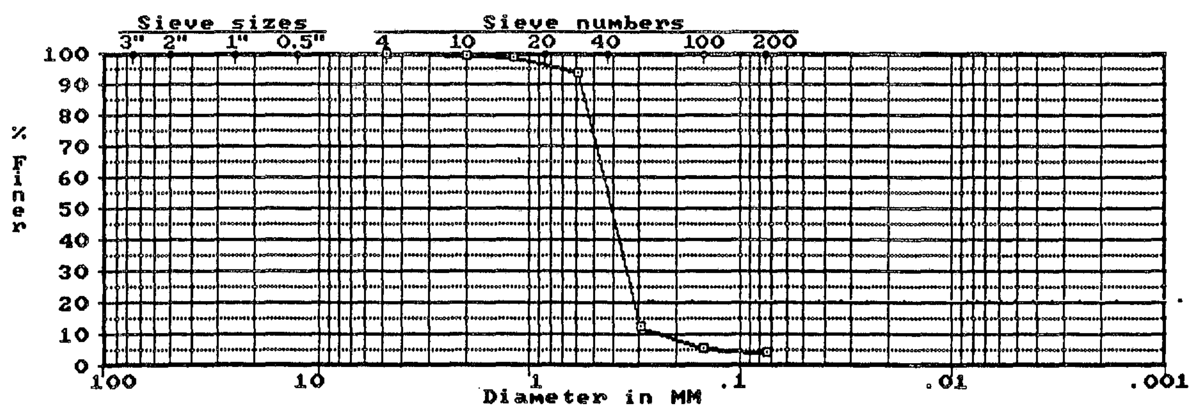
Gravel: 0.0% Sand: 95.9% Fines: 4.1%

------------------------- ASTM D 2487 Classification -------------------------

SP Poorly graded SAND

---------------------------------- Comments ----------------------------------

Percent finer than 0.02 mm unknown, therefore no frost classification.



* * * CORPS OF ENGINEERS - NORTH PACIFIC DIVISION LABORATORY * * *

COOK INLET (92-S-269)

Boring: -- Sample: 18-7 Depth: 17.5 M Lab No.: 26910

------ Sieve Analysis ------

No hydrometer analysis.

Sieve	Cumulative Grams Retained	Percent Passing
3 In.	0.00	100.0
2 In.	0.00	100.0
1.5 In.	0.00	100.0
1 In.	0.00	100.0
3/4 In.	0.00	100.0
1/2 In.	0.00	100.0
3/8 In.	0.00	100.0
No. 4	2.10	99.4
No. 10	3.00	99.2
Pan	368.00	0.0
No. 16	0.10	99.1
No. 30	8.40	89.2
No. 50	81.20	2.8
No. 100	82.60	1.2
No. 200	83.00	0.7
Pan	83.60	0.0

D85: 0.57 D60: 0.47 D50: 0.43 D30: 0.37 D15: 0.33 D10: 0.31 mm

Cu: 1.49 Cc: 0.93

Liquid Limit: NP Plasticity Index: NP

Fines Type Used for Classification: ML, SILT

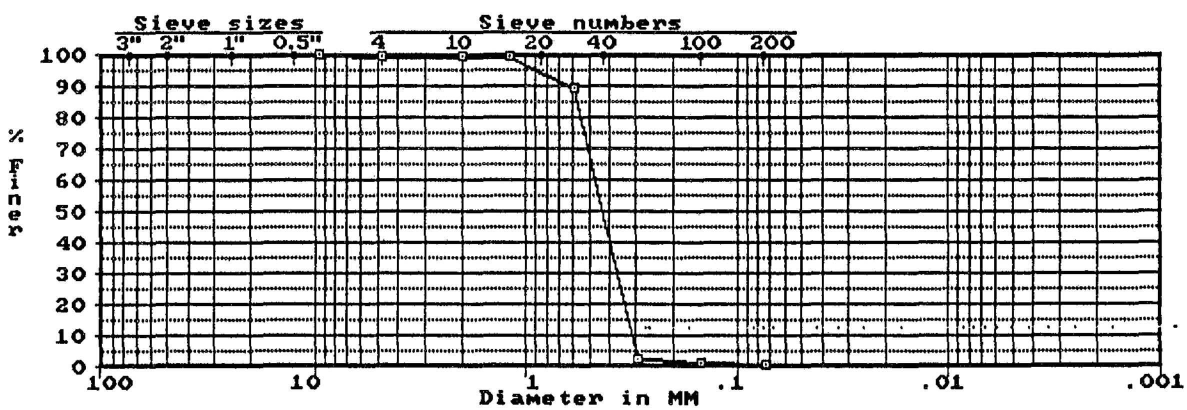
Gravel: 0.6% Sand: 98.7% Fines: 0.7%

------------------------- ASTM D 2487 Classification -------------------------

SP Poorly graded SAND

---------------------- TM 5-818-2 Frost Classification ----------------------

Frost Classification: NFS



* * * CORPS OF ENGINEERS - NORTH PACIFIC DIVISION LABORATORY * * *
COOK INLET (92-S-269)
Boring: -- Sample: 18-8 Depth: 18 M Lab No.: 26911

------ Sieve Analysis ------

Sieve	Cumulative Grams Retained	Percent Passing
3 In.	0.00	100.0
2 In.	0.00	100.0
1.5 In.	0.00	100.0
1 In.	0.00	100.0
3/4 In.	0.00	100.0
1/2 In.	0.00	100.0
3/8 In.	0.00	100.0
No. 4	0.00	100.0
No. 10	0.00	100.0
Pan	741.20	0.0
No. 16	0.60	99.3
No. 30	8.30	90.4
No. 50	84.10	3.2
No. 100	86.00	1.0
No. 200	86.30	0.7
Pan	86.90	0.0

No hydrometer analysis.

D85: 0.57 D60: 0.47 D50: 0.43 D30: 0.37 D15: 0.33 D10: 0.31 mm
Cu: 1.49 Cc: 0.93

Liquid Limit: NP Plasticity Index: NP
Fines Type Used for Classification: ML, SILT

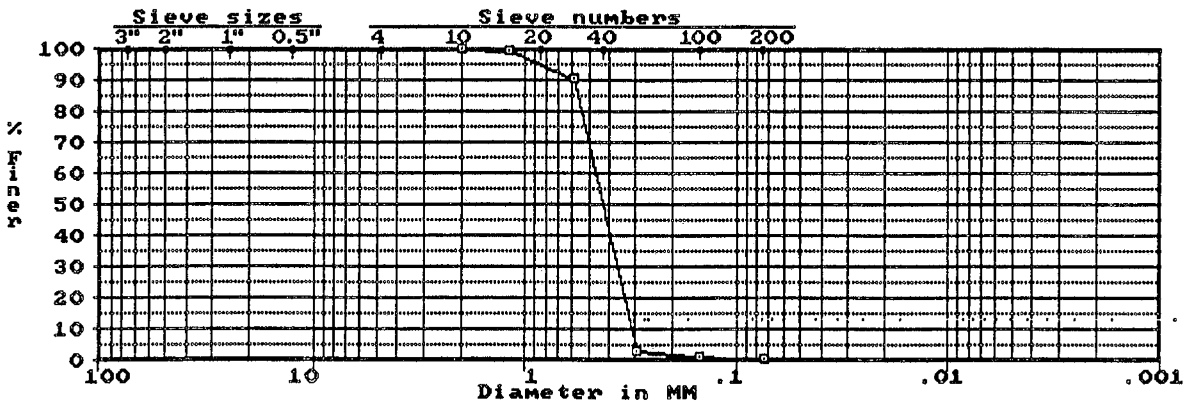
Gravel: 0.0% Sand: 99.3% Fines: 0.7%

------------------------ ASTM D 2487 Classification ------------------------

SP Poorly graded SAND

---------------------- TM 5-818-2 Frost Classification ----------------------

Frost Classification: NFS



* * * CORPS OF ENGINEERS - NORTH PACIFIC DIVISION LABORATORY * * *

COOK INLET (92-S-269)

Boring: -- Sample: 6115 Depth: 26.2 M Lab No.: 26912

------ Sieve Analysis ------

No hydrometer analysis.

Sieve	Cumulative Grams Retained	Percent Passing
3 In.	0.00	100.0
2 In.	0.00	100.0
1.5 In.	0.00	100.0
1 In.	0.00	100.0
3/4 In.	0.00	100.0
1/2 In.	0.00	100.0
3/8 In.	0.00	100.0
No. 4	0.00	100.0
No. 10	0.20	99.8
Pan	81.00	0.0
No. 16	1.50	97.4
No. 30	3.20	94.8
No. 50	53.50	16.6
No. 100	61.80	3.7
No. 200	63.60	0.9
Pan	64.20	0.0

D85: 0.54 D60: 0.43 D50: 0.40 D30: 0.33 D15: 0.27 D10: 0.21 mm

Cu: 2.07 Cc: 1.23

Liquid Limit: NP Plasticity Index: NP

Fines Type Used for Classification: ML, SILT

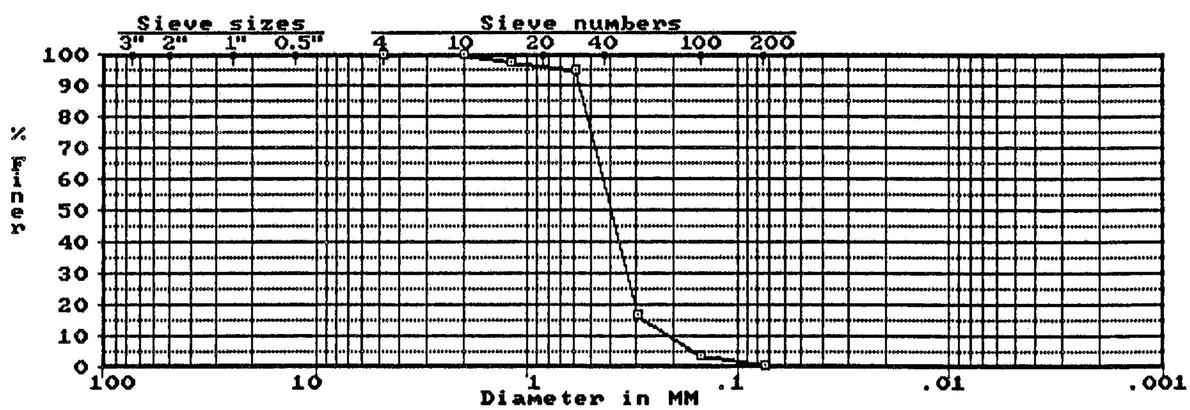
Gravel: 0.0% Sand: 99.1% Fines: 0.9%

------------------------- ASTM D 2487 Classification -------------------------

SP Poorly graded SAND

---------------------- TM 5-818-2 Frost Classification ----------------------

Frost Classification: NFS



* * * CORPS OF ENGINEERS - NORTH PACIFIC DIVISION LABORATORY * * *
COOK INLET (92-S-269)
Boring: -- Sample: 6427 Depth: 12.2 M Lab No.: 26923

------ Sieve Analysis ------

Sieve	Cumulative Grams Retained	Percent Passing
3 In.	0.00	100.0
2 In.	0.00	100.0
1.5 In.	0.00	100.0
1 In.	115.30	18.8
3/4 In.	115.30	18.8
1/2 In.	123.50	13.0
3/8 In.	130.70	8.0
No. 4	138.40	2.5
No. 10	140.70	0.9
Pan	142.00	0.0
No. 16	0.34	0.7
No. 30	0.66	0.5
No. 50	0.82	0.4
No. 100	1.01	0.3
No. 200	1.34	0.1
Pan	1.42	0.0

No hydrometer analysis.

D85: 35.7 D60: 31.8 D50: 30.3 D30: 27.2 D15: 14.2 D10: 10.7 mm
Cu: 2.97 Cc: 2.17

Liquid Limit: NP Plasticity Index: NP
Fines Type Used for Classification: ML, SILT

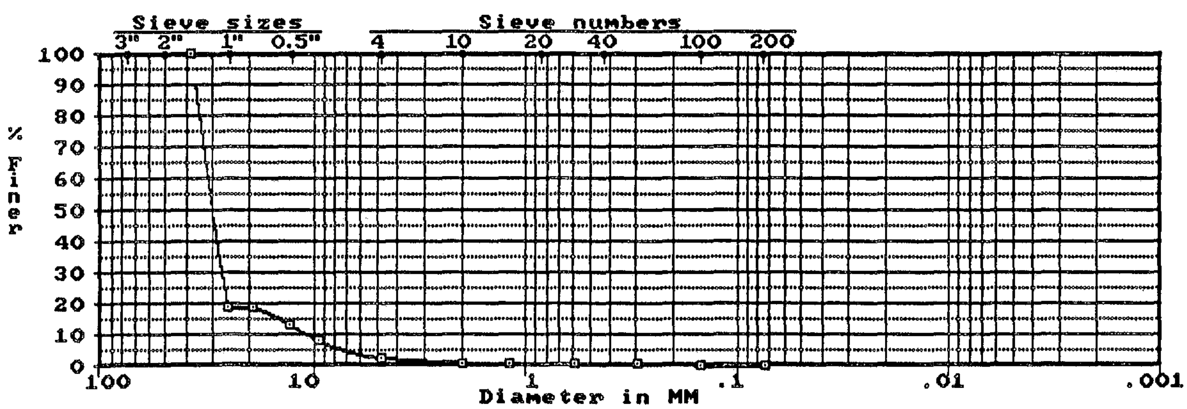
Gravel: 97.5% Sand: 2.4% Fines: 0.1%

------------------------- ASTM D 2487 Classification -------------------------

GP Poorly graded GRAVEL

--------------------- TM 5-818-2 Frost Classification ---------------------

Frost Classification: NFS



* * * CORPS OF ENGINEERS - NORTH PACIFIC DIVISION LABORATORY * * *
COOK INLET (92-S-269)
Boring: -- Sample: 6428 Depth: 15.3 M Lab No.: 26924

------ Sieve Analysis ------

No hydrometer analysis.

Sieve	Cumulative Grams Retained	Percent Passing
3 In.	0.00	100.0
2 In.	0.00	100.0
1.5 In.	0.00	100.0
1 In.	0.00	100.0
3/4 In.	0.00	100.0
1/2 In.	0.00	100.0
3/8 In.	0.00	100.0
No. 4	0.00	100.0
No. 10	0.00	100.0
Pan	74.30	0.0
No. 16	0.10	99.9
No. 30	1.40	98.1
No. 50	70.70	4.8
No. 100	72.30	2.7
No. 200	73.50	1.1
Pan	74.30	0.0

D85: 0.54 D60: 0.45 D50: 0.41 D30: 0.36 D15: 0.32 D10: 0.31 mm
Cu: 1.44 Cc: 0.93

Liquid Limit: NP Plasticity Index: NP
Fines Type Used for Classification: ML, SILT

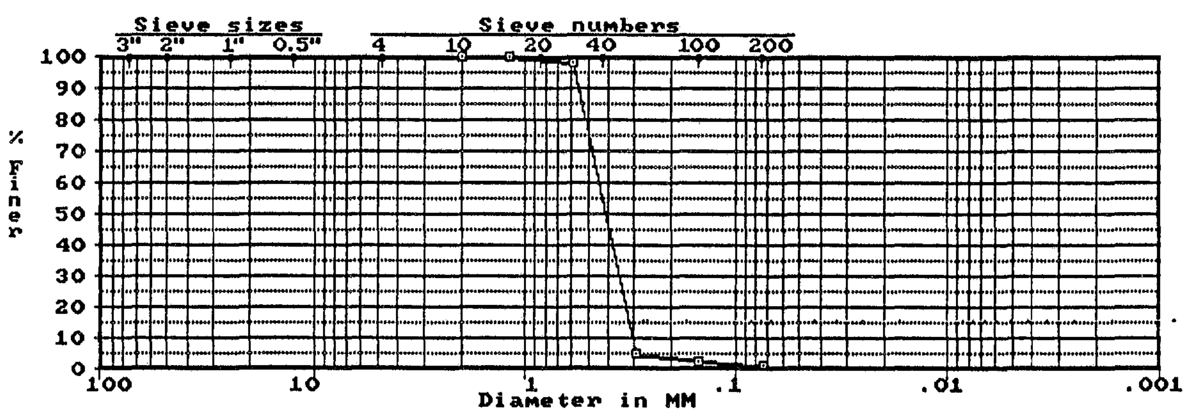
Gravel: 0.0% Sand: 98.9% Fines: 1.1%

--- ASTM D 2487 Classification ---

SP Poorly graded SAND

--- TM 5-818-2 Frost Classification ---

Frost Classification: **NFS**



* * * CORPS OF ENGINEERS - NORTH PACIFIC DIVISION LABORATORY * * *
COOK INLET (92-S-269)
Boring: -- Sample: 6428 Depth: 15.3 M Lab No.: 26924

------ Sieve Analysis ------

Sieve	Cumulative Grams Retained	Percent Passing
3 In.	0.00	100.0
2 In.	0.00	100.0
1.5 In.	0.00	100.0
1 In.	0.00	100.0
3/4 In.	0.00	100.0
1/2 In.	0.00	100.0
3/8 In.	0.00	100.0
No. 4	0.00	100.0
No. 10	0.00	100.0
Pan	74.30	0.0
No. 16	0.10	99.9
No. 30	1.40	98.1
No. 50	70.70	4.8
No. 100	72.30	2.7
No. 200	73.50	1.1
Pan	74.30	0.0

No hydrometer analysis.

D85: 0.54 D60: 0.45 D50: 0.41 D30: 0.36 D15: 0.32 D10: 0.31 mm
Cu: 1.44 Cc: 0.93

Liquid Limit: NP Plasticity Index: NP
Fines Type Used for Classification: ML, SILT

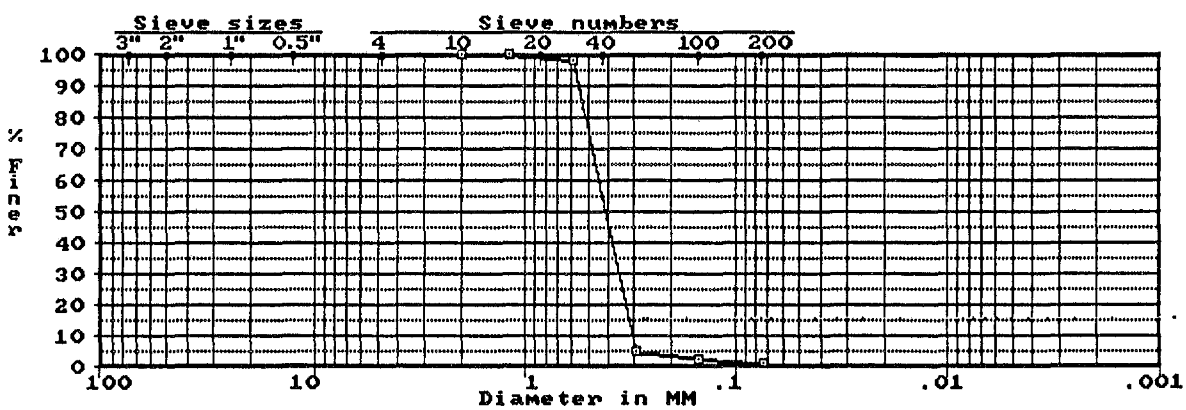
Gravel: 0.0% Sand: 98.9% Fines: 1.1%

------------------------- ASTM D 2487 Classification -------------------------

SP Poorly graded SAND

---------------------- TM 5-818-2 Frost Classification ----------------------

Frost Classification: NFS



* * * CORPS OF ENGINEERS - NORTH PACIFIC DIVISION LABORATORY * * *
COOK INLET (92-S-269)
Boring: -- Sample: 6435 Depth: 8.9 M Lab No.: 26931

------ Sieve Analysis ------

Sieve	Cumulative Grams Retained	Percent Passing
3 In.	0.00	100.0
2 In.	0.00	100.0
1.5 In.	0.00	100.0
1 In.	0.00	100.0
3/4 In.	0.00	100.0
1/2 In.	0.00	100.0
3/8 In.	2.50	99.1
No. 4	38.00	85.6
No. 10	81.00	69.3
Pan	263.90	0.0
No. 16	6.20	64.7
No. 30	11.20	61.0
No. 50	74.30	13.9
No. 100	88.20	3.6
No. 200	89.40	2.7
Pan	93.00	0.0

No hydrometer analysis.

D85: 4.63 D60: 0.58 D50: 0.50 D30: 0.37 D15: 0.30 D10: 0.23 mm
Cu: 2.54 Cc: 1.05

Liquid Limit: NP Plasticity Index: NP
Fines Type Used for Classification: ML, SILT

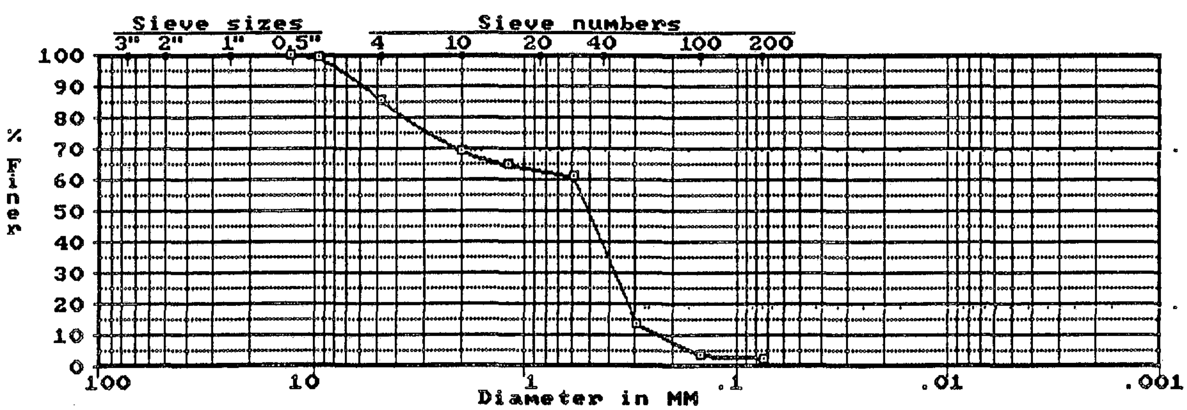
Gravel: 14.4% Sand: 82.9% Fines: 2.7%

------------------------ ASTM D 2487 Classification ------------------------

SP Poorly graded SAND

---------------------- TM 5-818-2 Frost Classification ----------------------

Frost Classification: NFS



* * * CORPS OF ENGINEERS - NORTH PACIFIC DIVISION LABORATORY * * *
COOK INLET (92-S-269)
Boring: -- Sample: 6436 Depth: 10.2 M Lab No.: 26932

------ Sieve Analysis ------

No hydrometer analysis.

Sieve	Cumulative Grams Retained	Percent Passing
3 In.	0.00	100.0
2 In.	0.00	100.0
1.5 In.	0.00	100.0
1 In.	0.00	100.0
3/4 In.	0.00	100.0
1/2 In.	0.00	100.0
3/8 In.	0.00	100.0
No. 4	0.30	99.9
No. 10	1.30	99.7
Pan	387.80	0.0
No. 16	0.30	99.3
No. 30	12.60	85.8
No. 50	88.20	2.6
No. 100	90.00	0.7
No. 200	90.20	0.4
Pan	90.60	0.0

D85: 0.59 D60: 0.48 D50: 0.44 D30: 0.37 D15: 0.33 D10: 0.32 mm
Cu: 1.52 Cc: 0.92

Liquid Limit: NP Plasticity Index: NP
Fines Type Used for Classification: ML, SILT

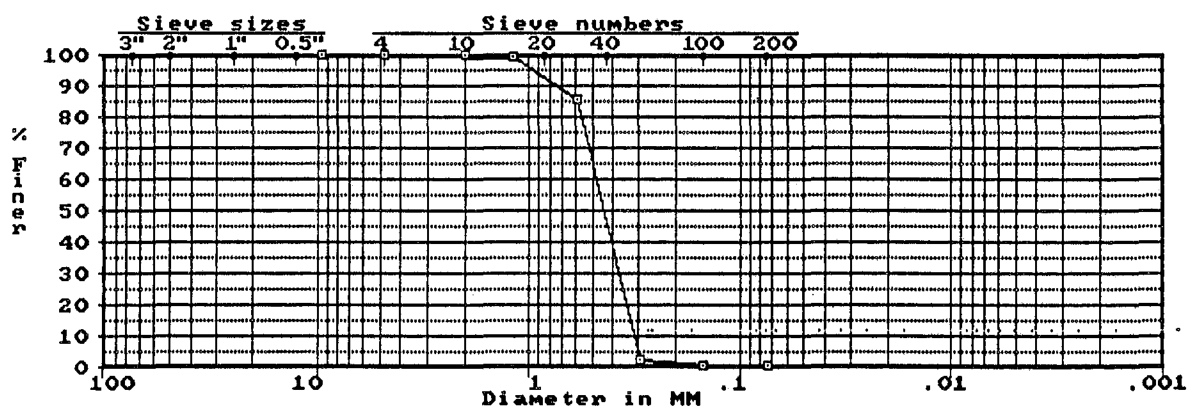
Gravel: 0.0% Sand: 99.5% Fines: 0.4%

------------------------ ASTM D 2487 Classification ------------------------

SP Poorly graded SAND

---------------------- TM 5-818-2 Frost Classification ----------------------

Frost Classification: NFS



* * * CORPS OF ENGINEERS - NORTH PACIFIC DIVISION LABORATORY * * *

COOK INLET (92-S-269)

Boring: -- Sample: 6437 Depth: 15.3 M Lab No.: 26933

------ Sieve Analysis ------

No hydrometer analysis.

Sieve	Cumulative Grams Retained	Percent Passing
3 In.	0.00	100.0
2 In.	0.00	100.0
1.5 In.	0.00	100.0
1 In.	0.00	100.0
3/4 In.	0.00	100.0
1/2 In.	0.00	100.0
3/8 In.	0.00	100.0
No. 4	2.50	99.3
No. 10	4.30	98.8
Pan	359.60	0.0
No. 16	0.40	98.3
No. 30	4.50	93.5
No. 50	76.30	8.4
No. 100	81.60	2.1
No. 200	82.40	1.2
Pan	83.40	0.0

D85: 0.55 D60: 0.45 D50: 0.42 D30: 0.35 D15: 0.31 D10: 0.30 mm

Cu: 1.50 Cc: 0.92

Liquid Limit: NP Plasticity Index: NP

Fines Type Used for Classification: ML, SILT

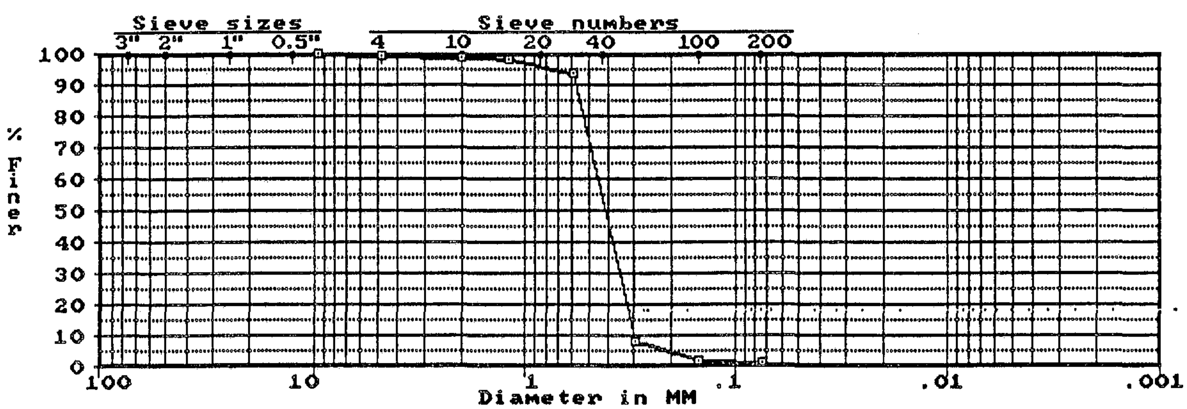
Gravel: 0.7% Sand: 98.1% Fines: 1.2%

------------------------- ASTM D 2487 Classification -------------------------

SP Poorly graded SAND

---------------------- TM 5-818-2 Frost Classification ----------------------

Frost Classification: NFS



APPENDIX C

ECONOMICS

CONTENTS--Continued

FIGURES

TABLES

TABLES--Continued

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April 1, 1993

APPENDIX C
ECONOMICS

Cook Inlet Navigation Study - Knik Arm Shoal

1. OVERVIEW

The economic analysis for the upper Cook Inlet navigation study focused on changes in transportation cost. Most of the benefits are derived from two firms which have dedicated cargo liner service to the Port of Anchorage. The transportation savings were from efficiencies gained by the existing transportation system and not from a reallocation of commodities to a more efficient fleet. All figures are for the years stated; the price level is that of October 1992.

2. LOCATION AND DESCRIPTION

The Port of Anchorage is located on the southeast side of Knik Arm at the northern end of Cook Inlet, Alaska. The port is 175 miles from the nearest entrance to Cook Inlet and 1,429 miles from Seattle, Washington. Anchorage is the State's largest city and is centrally located with respect to Interior Alaska and the Kenai Peninsula. Fairbanks, the second largest city, is 365 miles north of Anchorage and is linked to the Port of Anchorage by both the Alaska Railroad and the State's highway system. The Port of Anchorage was developed as the primary port of entry for Southcentral and Interior Alaska for general cargo. The development of containerization and trailer service capitalized on the port's central location, proximity to population centers, and access to rail and highway facilities. Semiweekly container and trailer services are operated by Sea-Land Service, Inc., and Totem Ocean Trailer Express (TOTE), respectively. Seasonal bulk barge services are operated by Delta Western, Alaska Marine, and other barge lines.

Along the 200-mile-long Cook Inlet are two shoals which regularly cause delays to shipping: Fire Island Shoal and Knik Arm Shoal. Fire Island Shoal historically has been navigated on the south side. The south-side channel has a controlling depth of -31 feet mean lower low water (MLLW) and is about 1.9 miles wide. Today Fire Island Shoal is navigated on the north side, where a controlling depth of -48 feet MLLW is available over a channel width of 2.25 miles. The focus of this study is Knik Arm Shoal. It is located about 2 miles west of Point Woronzof and 8 miles southwest of Anchorage. The shoal's crest is -11 feet MLLW. The natural channel, marked by two buoys during the ice-free season of May through October, has a controlling depth of -25 feet MLLW along its southern flank. (See figure 4-3, main report.)

3. EXISTING CONDITIONS

3.1 General

The existing condition is treated as that which existed in 1991. Operating procedures, labor contracts, and commodity data for 1991 were used to establish the existing condition. Operating procedures and labor contracts were taken from written correspondence and telephone interviews with the shippers and the stevedore union.

3.2 Vessel Operations

Sea-Land and TOTE have dedicated cargo liner services between the Port of Tacoma, Washington, and the Port of Anchorage. Sea-Land also provides feeder service to Kodiak, Alaska, on the return trip to Tacoma. Vessels carrying containerized cargo are scheduled to arrive at the Port of Anchorage at 7 a.m. This schedule is coordinated with the port, the stevedores, trucking firms, and the railroad. If the shippers arrive late, they are penalized by the stevedore rates, and they must reschedule with the truckers, the railroad, and their customers. Thus, late arrivals increase administrative costs and cause contractual problems. Departing vessels carry primarily seafood and empty containers.

3.3 Tide and Shoal Considerations

Inbound pilots prefer to navigate Cook Inlet between the Forelands and the Port of Anchorage on a flood tide when practical. The Forelands and the Port of Anchorage are about 50 miles apart. (See figure 2-9, main report.) Navigating on the flood tide allows more efficient operations and avoids a collision course with floating objects, such as winter ice floes.

Sea-Land and TOTE vessels can cross Knik Arm Shoal safely during an average high tide window of about 4 hours. When inbound pilots know they will arrive at the shoal too soon to have adequate under-keel clearance to pass over safely, they reduce speed to time their arrival at the shoal with high tide. Also, ice floes or storms occasionally cause the vessels to completely miss the high tide window for crossing the shoal, forcing a full tide cycle delay as they wait for the next high tide.

Once a vessel is offloaded at Anchorage, its operator must decide when to depart. Two shoal-related conditions may complicate this decision. First, the outbound vessel may face an upcoming tide window which may be met only if outbound cargo or empty containers are left behind. The departure decision must balance the timing of the tidal access, the need to load the cargo, and the need for the empty containers with the in-port cost associated with waiting for the next high tide window. Second, the outbound ship may be completely ready to sail but must sit idle at the dock waiting for the next high tide window. This leaves no decision; the vessel simply must wait for high tide.

4. WITHOUT-PROJECT CONDITION

The without-project condition is the most likely condition expected to exist over the life of the project in the absence of a Federal investment. Without the proposed channel excavation, container vessels will continue to experience shoal-induced delays and related problems. As commodity flows though the Port of Anchorage increase, the frequency of delays will increase proportionately.

5. WITH-PROJECT CONDITION

The with-project condition is the condition expected to exist over the period of analysis if the project is undertaken. For this reconnaissance report, one channel bottom elevation (-35 feet MLLW) was examined. Vessel operations were simulated to estimate the reduction in shoal-induced delays resulting from increased channel depth. During the feasibility phase of study, incremental depths from the existing shoal depth of -25 feet MLLW to depths well below -35 feet MLLW would be examined.

6. METHODOLOGY

Economic evaluation of the proposed channel improvement to the Knik Arm Shoal was conducted according to Engineering Regulation (ER) 1105-2-100, chapter 6, section VII, "NED [National Economic Development] Benefit Evaluation Procedures: Transportation, Deep-Draft Navigation," dated December 1990, and the Institute for Water Resources' "National Economic Development Procedures Manual: Deep Draft Navigation," dated 1991.

The economic benefits from the proposed Knik Arm Shoal project are the reduction in origin-to-destination transportation cost and the opportunity cost of time. The specific transportation savings result from reductions in fuel consumption, stevedore cost, administration cost, maintenance cost, and insurance. The opportunity cost of time benefits result from reduced transit times.

Project benefits were estimated by calculating the transportation cost for both with- and without-project conditions on a per-trip basis. Historical and existing commodity movements were examined to determine commodity throughput and trends in commodity flows. A commodity forecast was developed. Changes to the fleet serving Anchorage were examined to estimate the future fleet. The number of trips per year necessary to transport the future commodity flow was estimated by allocating the commodities forecasted to the future fleet based on 1991 conditions. Yearly transportation savings were estimated by multiplying the per-trip saving estimate times the number of trips per year through the planning period. Reduced costs were claimed as project benefits and compared to the project cost to derive a benefit-to-cost ratio.

Benefits attributable to the transportation of petroleum products were not quantified for this reconnaissance report. While the petroleum tonnage is close to the volume of general containerized cargo, the transportation savings are comparatively small because of the small number of trips per year. The benefits from transporting petroleum would be examined in the feasibility study.

7. PAST COMMODITY MOVEMENT

Prior to 1964, freight was moved throughout Southcentral Alaska by train from deep-water ports at Seward and Whittier. Steamship lines brought general cargo to Seward, where it was transferred to railcars and moved to the population centers at Anchorage, Palmer, and Fairbanks. From Seward, this involved a rail movement of about 125 miles to Anchorage and 365 miles to Fairbanks. The 125-mile section between Seward and Anchorage traverses some of the steepest grades and most difficult terrain found on the Alaska railroad system. Freight which required specialized handling, such as heavy machinery, pipes, and vehicles, was carried to Whittier by rail barge or train-ship and moved by the Alaska Railroad to major population centers.

Following the Good Friday earthquake of 1964, the port of Anchorage emerged as the only operable deep draft shipping facility in the region. As a result, major changes took place in waterborne transportation to the Alaska railbelt area. The steamship service to Seward was replaced by a modern fleet equipped to deliver containerized general freight to the developing Port of Anchorage. Freight could then be distributed by rail or truck to local businesses or to cities in the railbelt area. Import of materials in the 1970's for construction of the Trans-Alaska Oil Pipeline further accelerated development of the Port of Anchorage. General cargo tonnage through Anchorage increased from 398,000 tons in 1970 to 1,175,000 tons in 1980.

Table C-1 shows the historical flows of cargo through the Port of Anchorage. For the last five years (1987-1991) containers and trailer van traffic averaged 59.5 percent of throughput, petroleum traffic averaged 36.8 percent, and bulk commodities averaged 3.7 percent.

Containerized cargo and bulk petroleum accounted for nearly all tonnage through the Port of Anchorage in 1991. Of the 1,318,000 tons of containerized cargo handled in 1991, a little more than 1,200,000 tons were inbound, or about 91 percent. The decline in petroleum shipments during the early 1980's was due to the completion and use of a pipeline from the refinery at Nikiski to Anchorage. Petroleum shipments through the port have increased rapidly in recent years, from about 300,000 tons in 1982 to 925,000 tons in 1991. Just under 40 percent of petroleum tonnage in 1991 was inbound. Total cargo increased from 1,767,000 tons in 1982 to nearly 2,313,000 tons in 1991, an increase of about 31 percent, or an annual increase of about 2.7 percent.

Figure C-1 shows the yearly arrivals by vessel type from 1980 to 1991.

TABLE C-1.--*Historical commodity flows, Port of Anchorage, 1980-91 (tons)*

Commodity	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Freight	2,764	6,395	22,128	15,812	33,937	9,222	1,826	903	891	148	896	327
Cement	18,836	32,497	63,340	46,378	48,599	87,927	70,149	57,312	48,328	66,103	76,101	63,164
Coal	27,754	0	0	0	0	0	0	0	0	0	0	0
Insulation	1	1	0	0	0	0	0	0	0	0	0	0
Iron or steel	10,633	25,373	30,292	59,578	53,940	23,604	9,026	348	28	121	1	0
Lumber	355	2,279	14,316	26,570	13,899	1,726	65	0	6,727	2,873	14	25
Petroleum, NOS	3,021	2,166	3,929	3,831	5,399	6,272	3,084	271	1,684	1,189	747	2,358
Transshipped cargo	38,390	27,115	36,855	27,337	38,148	37,786	10,191	14,821	10,933	8,560	0	272
Vans, flats, containers	1,043,004	1,154,060	1,253,190	1,390,396	1,238,497	1,194,846	1,138,143	1,152,611	1,133,461	1,263,008	1,324,262	1,318,940
Vehicles	29,414	39,829	37,626	42,460	15,803	2,664	1,934	1,879	2,037	2,288	2,262	1,467
Petroleum, bulk	589,580	365,997	304,914	394,576	684,139	561,151	385,995	514,564	701,484	963,570	791,193	925,173
TOTAL	1,763,752	1,655,712	1,766,590	2,006,938	2,132,361	1,925,198	1,620,413	1,742,709	1,905,573	2,307,860	2,195,476	2,311,726

NOS = Not otherwise specified.

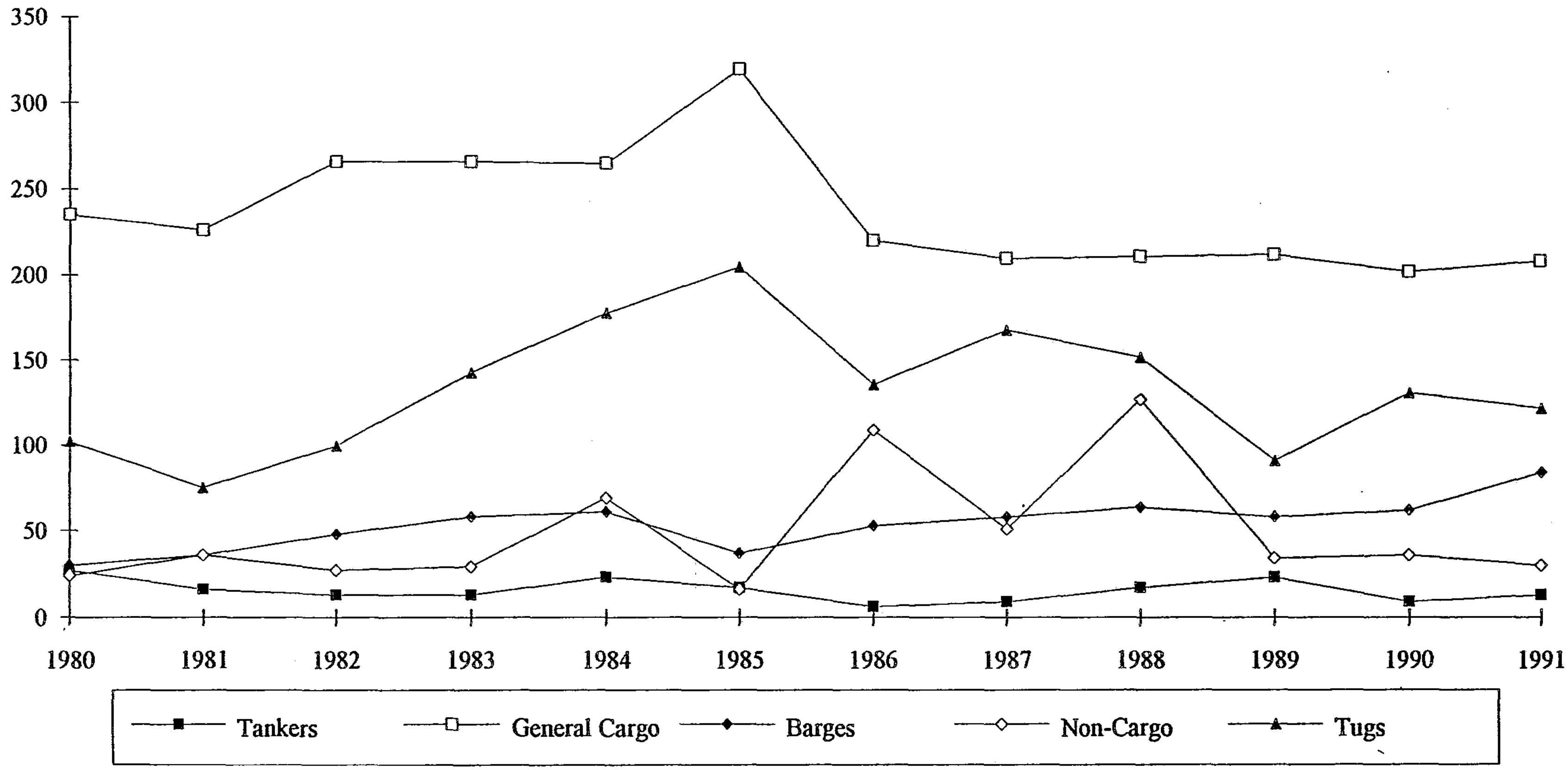

FIGURE C-1.--Port of Anchorage yearly vessel arrivals, 1980-91.

8. COMMODITY FORECAST

Future commodity flows were forecast to determine future project benefits.

8.1 Port of Anchorage

The Port of Anchorage will continue for the foreseeable future to be the dominant transshipment center of maritime commerce for Southcentral Alaska and the railbelt area for the following reasons:

a. It is closer to the population and commercial centers of the State than other Alaska ports, and more than half of Alaska's population lives within 50 miles.

b. It has relatively easy access to both rail and highway transshipment modes.

c. It is a year-round port now serving more than 80 percent of all Alaskans.

In the early 1980's, a containerized cargo terminal was constructed at the Port of Valdez. This did not result in a significant diversion from Anchorage to Valdez of cargoes bound for Interior Alaska (Fairbanks and nearby populated areas). Historical commodity flows support the conclusion that the Port of Anchorage will continue to dominate containerized cargo imports and exports for decades to come. The Port of Anchorage is actively pursuing improvement in shoreside traffic patterns, enlargement of storage and staging areas, and upgrades to its cargo handling equipment to improve its efficiency and secure its place in Alaska's transportation system.

The commodity forecast for the Port of Anchorage was based on estimates of future growth in total personal income. Projection of total personal income was taken from the Bureau of Economic Analysis' estimate for the Anchorage, Alaska, Metropolitan Statistical Area. The growth rate in personal income was calculated for each 10-year period from 1998 through 2048. The commodity base was then extrapolated at these rates. The commodity base was established by calculating the average annual commodity flow for the 5-year period 1987-1991. Table C-2 shows commodity projections for the planning period.

TABLE C-2.--*Port of Anchorage commodity forecast, 1998-2048 (tons)*

Commodity	Base year (1987-1991)	1998	2008	2018	2038	2048
Freight	633	693	771	849	957	1,104
Cement	62,202	68,091	75,768	83,401	94,069	108,511
Iron or steel	100	109	121	134	151	174
Lumber	1,928	2,110	2,348	2,585	2,915	3,363
Petroleum*	1,250	1,368	1,522	1,676	1,890	2,180
Transshipped cargo	6,917	7,572	8,426	9,275	10,461	12,067
Vans, flats, containers	1,238,456	1,355,708	1,508,571	1,660,553	1,872,948	2,160,492
Vehicles	1,987	2,175	2,420	2,664	3,004	3,466
Petroleum, bulk	779,197	852,968	949,144	1,044,767	1,178,398	1,359,312
TOTAL	2,092,669	2,290,793	2,549,093	2,805,903	3,164,794	3,650,668

* Not otherwise specified.

8.2 Coal

Alaska has enormous export potential for coal. Currently about 800,000 tons of coal are shipped each year through the Port of Seward. This coal comes from the Usibelli mine at Healy, about 360 miles north of Seward toward Fairbanks. Other potential sources of coal which might be shipped over the Knik Arm Shoal include the Wishbone Hill prospect near Palmer. Both the Port of Anchorage and the proposed Port MacKenzie could develop as alternative routes to market, since they are both closer to these coal locations than is Seward.

Both alternatives would involve exports via Panamax-class coal carriers which have a draft of about 42 feet fully loaded. These vessels would have to cross Knik Arm Shoal to reach either the Port of Anchorage or Port MacKenzie. Simulation of 30 arrivals of Panamax coal ships in 1991 tidal conditions indicates that an average delay on departure of more than 144 hours (6 days) could be expected, assuming the ships are fully loaded and require 10 feet of gross keel clearance. Excavation of a channel on Knik Arm Shoal to -35 ft MLLW would reduce these departure delays to an average of less than 5 hours. A channel improvement is clearly necessary before coal exports from above Knik Arm Shoal are practical.

The international market for coal at present appears to make these proposed new export facilities marginal endeavors. Coal exports through Seward have been recently proposed for various forms of State assistance to keep the current contract open. Worldwide demand for coal could change virtually any day as oil prices fluctuate and overall energy demands continue to increase. This reconnaissance report did not apply coal as a commodity to pass over the proposed channel because of the as-yet speculative nature of a Knik Arm coal port. Feasibility studies would address the question in more detail in order to optimize the channel depth.

8.3 Forest Products

No forest products are currently shipped out of the upper Cook Inlet. The Matanuska - Susitna Borough at the head of Cook Inlet has substantial stocks of timber available for export. This resource will probably be developed in the near future, most likely to produce wood chips for export. The chips would be transported via shallow draft barges which would not be significantly affected by the Knik Arm Shoal. For this reason, exports of timber products were not addressed in this analysis. The presence of a bulk export facility might induce timber-product exports in deep draft log ships. This prospect would be investigated further in the feasibility phase.

9. EXISTING FLEET

The majority of cargo passing through the Port of Anchorage has been carried by deep draft containerships or liquid-bulk petroleum vessels. A few dry-bulk carriers also call periodically. Many shallow draft barges and tugs also serve the upper Cook Inlet. Barge and tug traffic is not expected to be significantly affected by the proposed channel excavation.

9.1 Containerized Vessels

Dedicated liner service to the Port of Anchorage is provided by Sea-Land Service, Inc., and Totem Ocean Trailer Express (TOTE). Sea-Land has three containerized vessels: the *Anchorage*, the *Kodiak*, and the *Tacoma*. These vessels weigh 20,700 dwt (deadweight tons) and are equipped with 22,540 brake horsepower (BHP) propulsion systems. The Sea-Land vessels can carry 700 40-foot containers and have a maximum load of 7,854 tons. TOTE has two roll-on, roll-off (Ro/Ro) vessels: the *Greatland* and the *Westward Venture*. These vessels average 17,000 dwt and are equipped with 30,000-BHP propulsion systems. Each can carry 380 40-foot trailers and about 126 vehicles. Their maximum load is about 9,400 tons.

Both Sea-Land and TOTE vessels reach their volume constraint before their weight constraint. When bound for Anchorage during 1991, they averaged about 65 percent of their weight capacity. Table C-3 shows selected dimensions of the existing fleet.

TABLE C-3.--*Existing fleet containership characteristics*

Name	Weight (dwt)	Type	Loaded draft (ft)	Length (ft)	Beam (ft)
Sea-Land					
Anchorage	20,700	container	34.5	710	78
Kodiak	20,700	container	34.5	710	78
Tacoma	20,700	container	34.5	710	78
TOTE					
Greatland	16,100	RO/RO	29	790	105
Westward Venture	17,900	RO/RO	29	790	105

9.2 Petroleum Vessels

Five petroleum tankers called at the Port of Anchorage in 1991. They are listed in table C-4 by name, weight, loaded draft, length, and beam.

TABLE C-4.--*Characteristics of petroleum vessels calling at Anchorage (1991)*

Name	Weight (dwt)	Loaded draft (ft)	Length (ft)	Beam (ft)
Colorado	39,000	37	651	96
Sealift Antarctic	27,200	35	587	84
Star Montana	27,000	34	605	78
Flamenco	45,000	37	600	106
Alkuwaitah	35,000	36	600	106

10. TRANSPORTATION COST WITH AND WITHOUT THE PROJECT

Origin-to-destination transportation costs were estimated for the shippers' present operating procedures. Transportation costs from the ultimate point of origin to the Port of Tacoma, Washington, would not be affected by the project and were not addressed in this analysis. Transportation costs estimated from the Port of Tacoma to the Port of Anchorage included both vessel-related costs and shoreside costs.

10.1 Changes in Vessel-Related Cost

Operating costs for the containerized vessel fleet were estimated using the Corps of Engineers' Economic Guidance Memorandum (EGM) 92-4, "Fiscal Year 1992, Deep Draft Vessel Cost Estimates." Specific categories of cost for fuel consumption, administration, insurance, and maintenance were also estimated from data provided by the shippers.

10.1.1 Fuel Savings. Fuel consumption was estimated using adjusted consumption functions from EGM 92-4. The consumption functions published in that memorandum are an average based on a national sample. Vessels which operate in the upper Cook Inlet are significantly different from this average, having much larger engines for their size. The consumption functions were adjusted to reflect this difference. Adjusted functions were provided by the Corps' Headquarters office, Policy and Planning Division, Economic and Social Analysis Branch (personal communication, William C. Counce).

Shoal-induced delays in general cause an increase in fuel consumption. When pilots reduce speed to time their arrivals at the shoal at high tide, there are two countervailing fuel consumption effects. At the reduced speed, the vessels have a slightly reduced consumption rate; however, the transit time is increased, and the vessel consumes fuel for a longer period of time.

Interviews with the vessel operators indicate that changes in fuel consumption associated with changes in speed would not be significant. This reconnaissance report ignores changes in the consumption rate effect, and fuel consumption is considered a function of the duration of the voyage.

An increase in transit time (*i.e.*, arrival delay) results in a significant increase in total fuel consumption. The shoal-induced arrival and departure delays were estimated using a computer model. The shoal-induced delay times estimated in 1991 conditions with and without the project are presented in table C-5. Estimated delay times were computed by the Cook Inlet Ship Transit Simulation Model. See appendix D for a detailed description of the model.

TABLE C-5.--*Estimated average delay times in hours per transit*

Carrier	No. ships	Without project		With project		Time savings with project	
		Arrival delay	Departure delay	Arrival delay	Departure delay	Arrival	Departure
Sea-Land	101	3.2	0.6	1.2	0.1	2.0	0.5
TOTE	98	4.8	1.1	2.8	0.0	2.0	1.1

The average hourly change in transit time per trip was multiplied by the consumption rate and a representative price of fuel ($15 per barrel) to estimate the fuel savings per trip. This average savings per trip was multiplied by the number of trips per year to estimate annual savings. Table C-6 displays the fuel cost savings calculations through the 50-year planning period.

10.1.2 Changes in Crew Utilization Rate. The key to realizing crew utilization benefits is for the vessels to make more trips with the same crew time. Crews now typically work 4-months-on, 4-months-off. The crew stays on duty for the entire 4-month period. If the company cannot increase the number of trips, there are no NED benefits in this category. This analysis assumes that the shippers' ability to take advantage of the time savings with the project would increase in the first 10 years of the project to a maximum in year 2008 and remain thus thereafter. If utilization occurred earlier, the benefits would increase; later realization would yield lower benefits. Table C-7 shows the calculations for crew utilization savings.

10.2 Changes in Shoreside Cost

Changes in shoreside cost include stevedore, administration, insurance, and maintenance. These categories of shoreside cost are discussed incrementally in the following paragraphs.

10.2.1 Early and Aborted Callouts of Stevedores. The stevedore compensation structure negotiated between shipping and stevedore companies plays a significant role in stevedore costs associated with tidal delay of arrival and departure of ships. If shippers call out the stevedores after 1900 hours, they must pay overtime rates. The overtime rate applies because of the starting time, not the time worked. To avoid the overtime rate, the shippers will occasionally call out stevedores early and have them sit idle until the ship arrives. To estimate the idle time, 1991 data provided by the Port of Anchorage were reviewed to determine the number of arrivals between 1900 and 2400 hours. It was assumed that the shipper called out the stevedores prior to 1900 hours to avoid the overtime rates. The difference between the actual arrival time and 1900 hours was idle time. With the project in place, this idle time was assumed to be eliminated.

TABLE C-6.--*Fuel cost savings*

	1998	2008	2018	2028	2038	2048
Commodity forecast[a]	$1,355,708	$1,508,657	$1,660,554	$1,736,803	$1,872,948	$2,160,492
Market share[b]						
Sea-Land	$673,380	$749,350	$824,797	$862,670	$930,293	$1,073,116
TOTE	$682,328	$759,307	$835,757	$874,133	$942,655	$1,087,376
Trips/yr[c]						
Sea-Land	118	131	145	151	163	188
TOTE	120	133	147	153	165	191
Reduced fuel cost/ trip[d]						
Sea-Land	$751	$751	$751	$751	$751	$751
TOTE	$1,336	$1,336	$1,336	$1,336	$1,336	$1,336
Fuel savings/yr[e]						
Sea-Land	$88,618	$98,381	$108,895	$113,401	$122,413	$141,188
TOTE	160,320	177,688	196,392	204,408	220,440	255,176
Total fuel savings/yr	$248,938	$276,069	$305,287	$317,809	$342,853	$396,364

Average annual equivalent fuel savings over a 50-year period @ 8.25% annual interest = $304,000.

[a] The commodity forecast was based on the growth in personal income in Anchorage, Alaska (MSA-0380). Source: U.S. Department of Commerce, Bureau of Economic Analysis 1990 (Oct).

[b] The amount of cargo carried on the Sea-Land and TOTE trips was based on the share of cargo volume the shippers carried in 1991.

[c] The number of trips was estimated by dividing the market share by the average tons carried per trip.

[d] Fuel savings per trip was calculated as reduced fuel cost per trip = (hours saved per trip) * (cost per hour).

[e] Savings per year = (number of trips) * (savings per trip).

TABLE C-7.--*Crew utilization savings*

	1998	2008	2018	2028	2038	2048
Trips/yr[a]						
Sea-Land	118	131	145	151	163	188
TOTE	120	133	147	153	165	191
Hours saved/trip						
Sea-Land	0	2.53	2.53	2.53	2.53	2.53
TOTE	0	3.07	3.07	3.07	3.07	3.07
Labor rate ($/hour)						
Sea-Land[b]	$375	$375	$375	$375	$375	$375
TOTE[c]	$518	$518	$518	$518	$518	$518
Cost savings/yr						
Sea-Land	$0	$124,286	$137,569	$143,261	$154,646	$178,365
TOTE	0	211,505	233,768	243,310	262,393	303,740
Total cost/yr	$0	$335,791	$371,337	$386,571	$417,039	$482,105

Average annual equivalent of increased use of crew over a 50-year period at 8.25% annual interest = $262,000.

[a] The number of trips was based on the commodity forecast from table C-2.
[b] The hourly rate calculation was supplied by Sea-Land.
[c] The TOTE wage calculation was estimated by using Sea-Land's average hourly wage rate.

The wages lost by the stevedores would be costs saved by the shipper, resulting in no net change in national income. The NED gain would be the value of the stevedores' time now spent waiting due to early or aborted callouts. This time is valued as leisure, at one-third of the stevedores' wage rates.

Stevedores require advance notice before being called out. TOTE reports instances when stevedores are called out only to have the ship miss the tide window and not be able to reach the dock. In these cases, the stevedores are sent home. The project would potentially eliminate these occurrences of aborted stevedore callouts.

Table C-8 shows the calculation of savings through the planning horizon for preventing early callouts, and table C-9 the savings for preventing aborted callouts. The stevedores' time savings was valued as leisure time.

TABLE C-8.--*Opportunity cost savings from eliminating TOTE early callouts*

	1998	2008	2018	2028	2038	2048
Trips/year	118	131	145	151	163	188
Idle hours per trip	0.58	0.58	0.58	0.58	0.58	0.58
No. of stevedores	80	80	80	80	80	80
Opportunity cost of time ($/hour)	$16.00	$16.00	$16.00	$16.00	$16.00	$16.00
Total per year	$87,603	$97,254	$107,648	$112,102	$121,011	$139,571

Average annual equivalent opportunity cost savings from avoiding TOTE early callouts over a 50-year period @ 8.25% interest = $108,000.

TABLE C- 9.--*Opportunity cost savings from eliminating aborted callouts*

	1998	2008	2018	2028	2038	2048
No. of aborted callouts[a]	6	7	7	7	8	9
Opportunity cost of time[b]	$4,333	$4,333	$4,333	$4,333	$4,333	$4,333
Savings/yr	$26,000	$30,331	$30,331	$30,331	$34,664	$38,997

Average annual equivalent savings over a 50-year period @ 8.25% interest = $30,000.

[a] TOTE reported 5 aborted callouts for 1992. The number of such "false" callouts was assumed to increase with the number of trips made to the Port of Anchorage each year.

[b] One aborted callout costs TOTE $13,000 in labor charges. The opportunity cost was taken to be 1/3 of $13,000, or $4,333.

10.2.2 Stevedores' Time Waiting To Cast Off. Shippers must call out stevedores to cast off departing vessels. TOTE ships require 7 people, and Sea-Land ships require 8 people. While a ship waits at the dock for a tide window, the stevedores stand idle. The project would reduce the time waiting at the dock and reduce the labor input required per trip. The freed labor time was valued as leisure time. Table C-10 shows the estimation of cast-off savings.

TABLE C-10.--*Savings in time waiting to cast off from port*

	1998	2008	2018	2028	2038	2048
Trips/yr[a]						
Sea-Land	120	133	147	153	165	191
TOTE	118	131	145	151	163	188
Cast-off time/trip						
Sea-Land	0.47	0.47	0.47	0.47	0.47	0.47
TOTE	1.08	1.08	1.08	1.08	1.08	1.08
No. people casting off/ trip[b]						
Sea-Land	8	8	8	8	8	8
TOTE	7	7	7	7	7	7
Opportunity cost of time[c]						
Sea-Land	$16	$16	$16	$16	$16	$16
TOTE	$16	$16	$16	$16	$16	$16
Savings/yr						
Sea-Land	$7,219	$8,001	$8,844	$9,204	$9,926	$11,491
TOTE	$14,273	$15,846	$17,539	$18,265	$19,716	$22,740
Total savings/yr	$21,492	$23,847	$26,383	$27,469	$29,642	$34,231

Average annual equivalent cast-off savings over a 50-year period @ 8.25% interest = $27,000.

[a] The number of trips was based on the commodity forecast from table C-2.
[b] The number of stevedores casting off the vessel was supplied by Sea-Land and TOTE.
[c] The opportunity cost of time was valued as leisure time, which was based on 1/3 the hourly wage rate.

10.2.3 Administrative Savings. Administrative savings were estimated by the shippers. These savings result from the elimination of disrupted schedules and the consequent need to reschedule with truckers, the railroad, and customers, usually involving overtime labor. With the project in place, it was assumed the time currently spent rescheduling would be used for other administrative duties. This would reduce the need for overtime administrative labor. For estimation of NED benefits, the administrative labor cost saving was assumed to increase steadily from zero in the first year to a maximum in year 10 of the project. The annual savings was indexed to reflect the increase in trips per year. Table C-11 presents results of the calculations for Sea-Land and TOTE over the 50-year planning schedule.

TABLE C-11.--*Administrative savings*

	1998	2008	2018	2028	2038	2048
Trips/yr						
Sea-Land	118	131	145	151	163	188
TOTE	120	133	147	153	165	191
Savings/yr						
Sea-Land	$0	$38,118	$41,956	$43,883	$47,322	$54,588
TOTE	$0	$67,953	$74,795	$78,229	$84,362	$97,313
Total cost/yr	$0	$106,071	$116,751	$122,112	$131,684	$151,901

Average annual equivalent administrative savings over a 50-year period @ 8.25% interest = $53,000.

10.2.4 Maintenance. Expected savings in maintenance costs of $200,000 were reported by the shippers. Examination of these savings indicated that they were primarily financial transfers between the shipper and the maintenance crews and not NED benefits. Insufficient data were available to accurately isolate the NED portent. The reported saving was reduced to $5,000 to reflect the same ratio of financial transfer to NED benefits found in the cast-off benefit category.

10.2.5 Insurance. One shipper reported an expected reduction in insurance premiums. The average annual equivalent value was $75,000. It was expected that the project, with annual surveys and improved navigational aids, would lower the risk of traversing the shoal and that this would be reflected in the insurance premiums.

10.3 Total Estimated Savings

Table C-12 summarizes the benefit categories and total benefits. Information for several of the benefit calculations was provided by the major shippers in correspondence, particularly a letter from TOTE dated November 24, 1992, and one from Sea-Land dated December 2, 1992. Both letters are included in appendix E.

TABLE C-12.--*Total transportation savings (October 1992 price level)*

Category	Average annual equivalent amount
Sea-Land	
Fuel	$108,000
Crew utilization	97,000
Administrative	30,000
Maintenance	5,000
Subtotal	$240,000
TOTE	
Fuel	$196,000
Crew utilization	165,000
Insurance	75,000
Administrative	53,000
Maintenance	5,000
Subtotal	$494,000
Opportunity cost of time	
Cast-off	$27,000
Early callouts	108,000
Aborted callouts	30,000
Subtotal	$165,000
TOTAL ANNUAL BENEFITS	$899,000

11. PROJECT COST

Table C-13 summarizes project cost. Detailed estimates for initial excavation and maintenance dredging can be found in appendix B.

TABLE C-13.--*Average annual cost estimate*

Initial excavation	$2,280,000
Interest during construction (3 mo @ 8.25%)	16,000
Total first cost	$2,296,000
Interest & amortization (50 years @ 8.25%)	$193,000
Surveys and maintenance dredging	201,000
Total annual cost	**$ 404,000**

12. BENEFIT-TO-COST RATIO

Average annual benefits of $899,000 divided by the average annual cost of $404,000 yields a benefit-to-cost ratio of 2.3.

13. RISK AND UNCERTAINTY ANALYSIS

The economic analysis was developed based on many assumptions, both implicit and explicit. Some of these assumptions were explicitly expressed as point estimates of future conditions, *e.g.* the commodity forecast. Others were implicit in the calculation; for example, the per-trip fuel cost was estimated using $107 per ton. None of these point estimates were likely to be correct, but they represented a best guess of future conditions. The purpose of this section is to explore the sensitivity of project feasibility to the assumptions made.

13.1 Methodology

Key variables used to estimate project benefits were examined for each category. A variance and distribution were qualitatively considered for each key variable. Based on this qualitative information, a gross variance and distribution were estimated for the benefit category. The separate benefit categories and their respective distributions were integrated using the @RISK application for Lotus 1-2-3 software. (@RISK is a registered trademark of Palisade Corporation. Lotus and 1-2-3 are trademarks of Lotus Development Corporation.)

Project costs were also considered. Economic justification was not expected to be affected by the uncertainty associated with the first cost estimate, which is considered to be reliable. Considerable uncertainty was identified in the expected operation and maintenance (O&M) cost. Dredged quantity estimates varied from zero to more than $3 million in a single year. The cost was allowed to vary concurrently with the benefit estimate and the resulting benefit-to-cost ratio calculated.

13.2 Global Assumptions

A global assumption affects all benefit categories. Uncertainty in a global assumption results in uncertainty in the benefit category. The primary global assumptions for this study were the commodity forecast and the vessel utilization rate.

The commodity forecast was compared with a forecast made by the Southcentral Ports Development Project, a study conducted by Peratrovich, Nottingham and Drage (PN&D) for the State of Alaska (1993). PN&D made forecasts for three future conditions described as low, most likely, and high. The commodity forecast used in this analysis was comparable to PN&D's low forecast. Increases in the commodity flow beyond those projected in this report would result in greater benefits than estimated. The commodity forecast made for this analysis was judged to be on the low side.

The vessel utilization rate (cargo load versus ship capacity) was based on 1991 conditions. The 1991 utilization rate averaged 65 percent. The rate varies with the level of competition, quantity of commodity flows, season, and market share. An increased vessel utilization rate would result in fewer trips per year and lower benefits than estimated, if all other factors remain unchanged.

13.3 Estimates of Uncertainty in Benefit Categories

13.3.1 Fuel Cost. Fuel cost estimates per trip vary with the vessel consumption rate and the price of fuel. The consumption rate varies with the type and speed of the vessel. The vessel consumption rate was not expected to be a significant source of uncertainty, since the vessels are expected to remain relatively uniform in design. The price of fuel has varied from $9 per barrel to $27 per barrel in the last 2 years. In accordance with EGM 92-4, a representative price of $15 per barrel was used in this analysis. To account for the variance in the price of fuel and the global assumptions, the benefit point estimate was assigned a normal distribution with a standard deviation equal to 25 percent of the point estimate (mean).

13.3.2 Crew Utilization Rate. The key to realizing crew utilization benefits is for the vessels to make more trips with the same crew time. Each of the shippers schedules 2 visits per week to Anchorage, or 104 trips per year. In 1991 TOTE made 98 trips and Sea-Land made 102 trips. Within the existing operating schedule, more trips can be made. Moreover, with TOTE's addition of the vessel *Northern Lights*, additional trips and/or feeder services will need to be made to justify having six ships serving the Port of Anchorage. The uncertainty in this benefit category was judged to be related primarily to uncertainty in the commodity forecast. To reflect this, the point estimate was given a triangular distribution with a minimum value 10 percent lower than the point estimate and a maximum value 30 percent above the first estimate.

13.3.3 Opportunity Cost of Time for Stevedores. The uncertainty in this category was directly related to the number of trips per year and the value placed on the stevedores' time. The number of trips per year depends on the commodity forecast and the vessel utilization rate. The stevedores' time was valued as leisure time (one-third the wage rate). The Corps' Institute for Water Resources' report 91-R-12 summarizes research which estimates leisure time between 54 and 65 percent of the wage rate. The point estimate was allowed to vary using a uniform distribution with a minimum value equal to the point estimate and the maximum value equal to twice the point estimate.

13.3.4 Administrative Savings. The savings related to the number of missed schedules are related to the number of trips per year. This category accounts for the lost time of the shippers only and fails to consider the truckers, the railroad, and the customers. To reflect this deficiency, the benefit category was assigned a uniform distribution with a minimum value equal to the point estimate and a maximum value of three times the point estimate.

13.3.5 Early Stevedore Callouts. Benefits realized from the elimination of early callouts of stevedores are directly related to the number of trips per year. This benefit category was assigned a normal distribution with a standard deviation assumed to equal 10 percent of the mean value.

13.3.6 Insurance. Savings in insurance cost was estimated by a shipper. Only one shipper reported expected savings. Premiums typically reflect the actuarial risk involved, based on historical damage statistics. Any premium reductions would reflect a demonstrably reduced risk of grounding. Because only one shipper reported expected insurance savings, the estimate in insurance savings was assigned alternate values of zero and the point estimate. Each was given an equal probability of occurrence.

13.3.7 Maintenance. Maintenance benefits accounted for less than 2 percent of the total annual benefits. Their uncertainties were ignored in this analysis.

13.4 Uncertainty in Average Annual Cost Estimate

The estimate of average annual cost is based on a limited understanding of the sediment transport regime at the project site. Estimates of maintenance dredging quantities varied from no maintenance to dredging resulting from massive migration of nearby shoals across the proposed channel. If no maintenance were required, the average annual cost for periodic surveys alone would be $223,000. The most likely case estimate is $404,000 annually. The scenario described as case D in appendix B was used to estimate the 90-percent worst case average annual cost of $919,000. For this risk and uncertainty analysis, the average annual cost estimate was assigned a triangular distribution using these three points.

13.5 Results of Risk Analysis

Average annual benefits were calculated by randomly selecting a value for each benefit category and associating a probability based on its assumed probability density function. The results of all categories were summed to yield a total benefit estimate. An average annual cost was then randomly selected and associated with a probability based on its assumed probability function. The resulting benefit-to-cost ratio was then calculated and associated with a combined probability. This process was repeated 5,000 times. Figure C-2 shows the resulting distribution of the benefit-to-cost ratios. The minimum value was 0.6, the maximum 4.1 and the expected value 1.8. Figure C-3 shows the distribution of average annual cost and average annual benefits, and figure C-4 shows the cumulative benefit-to-cost-ratio curve in terms of combined probability. Figure C-4 shows that 94.4 percent of the 5,000 iterations had benefit-to-cost ratios above 1.0. This result implies that feasibility of the proposed project is highly likely at the conclusion of feasibility phase studies.

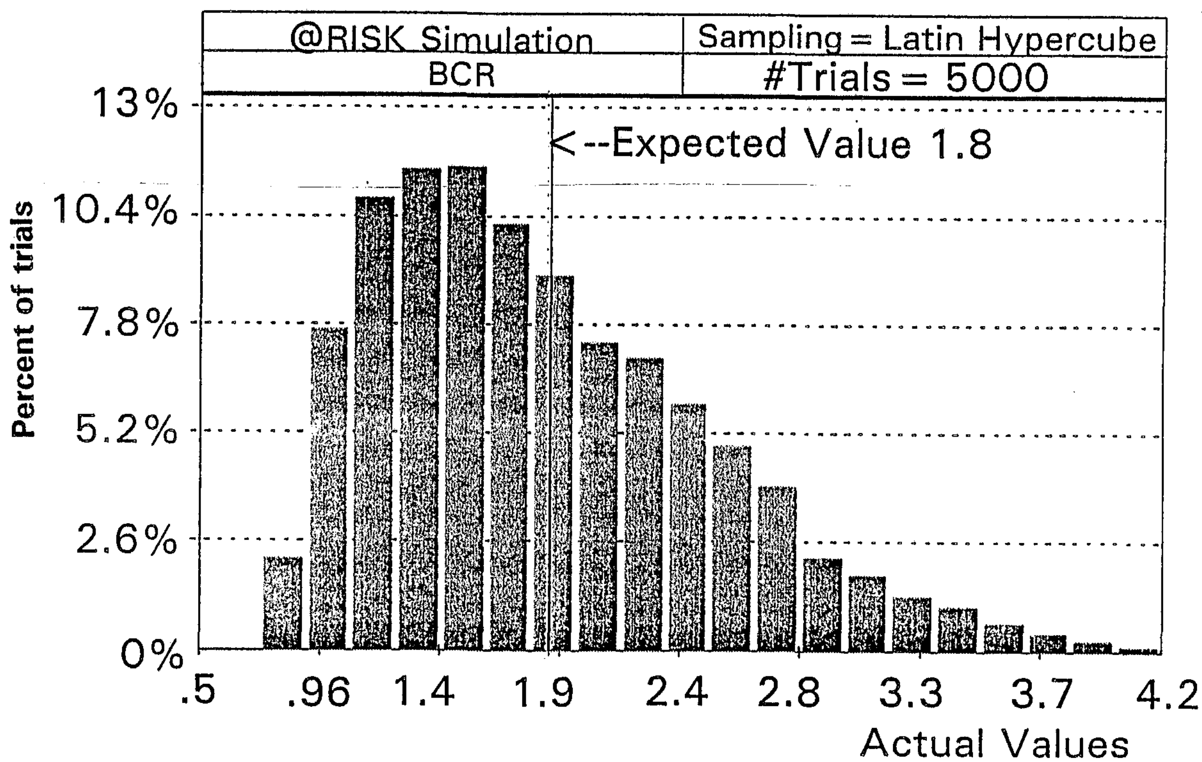

FIGURE C-2.--Benefit/cost ratios.

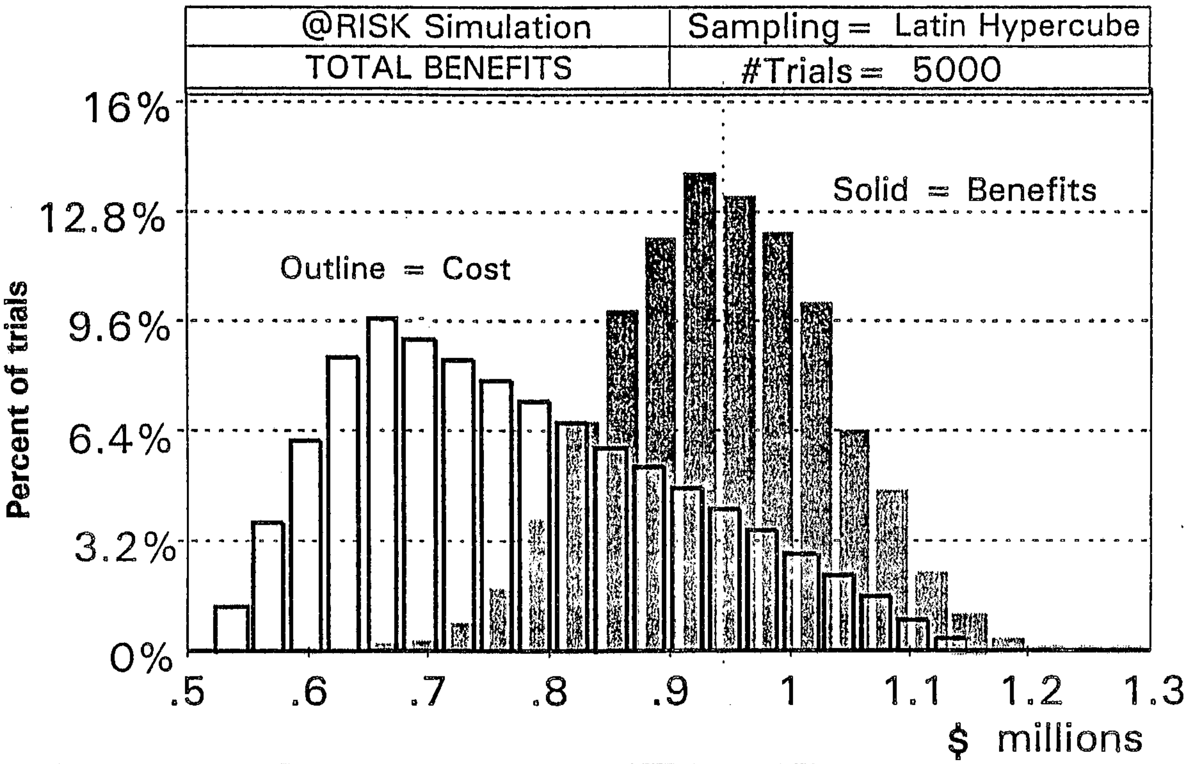

FIGURE C-3.--Benefits and cost.

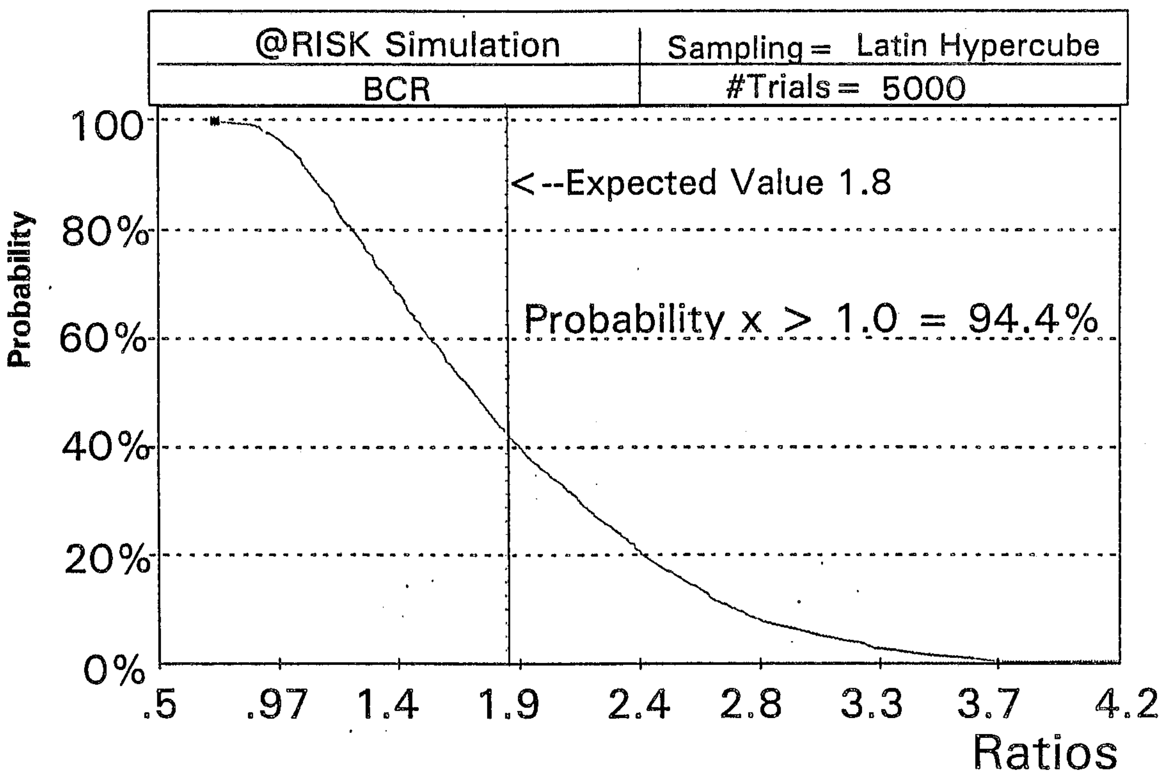

FIGURE C-4.--Cumulative benefit/cost ratios.

14. CONCLUSIONS

The risk and uncertainty analysis did not consider the variability in the estimated delay times calculated by the ship transit simulation model described in appendix D. The economic analysis is totally dependent on the output from the transit model for its conclusions. This issue would be investigated further in the feasibility phase.

This risk and uncertainty analysis also did not consider the effect of a Federal channel with respect to required underkeel clearance. Presently, 10 feet of underkeel clearance is required by the vessel operators and insurance underwriters. A federally maintained channel with annual surveys may reduce the required underkeel clearance. This issue would be investigated further in the feasibility phase.

Economic feasibility was not found to be affected by the uncertainty associated with the channel maintenance cost.

A navigation channel removing the Knik Arm shoal obstruction was found to be in the Federal interest. The risk and uncertainty analysis demonstrates the apparent economic feasibility of a channel dredged to -35 feet MLLW. It is recommended that feasibility studies be undertaken to examine the channel depth and width which would maximize benefits.

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APPENDIX C
ECONOMICS

CONTENTS

APPENDIX D

SHIP TRANSIT SIMULATION

APPENDIX D
SHIP TRANSIT SIMULATION

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TABLES

FIGURES

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APPENDIX D
SHIP TRANSIT SIMULATION

Introduction

The Cook Inlet Navigation Reconnaissance Study, begun by the Alaska District, U.S. Army Corps of Engineers in November 1991, was tasked to quantitatively assess the delays and inconvenience suffered by deep draft vessels due to a series of shoals in upper Cook Inlet. Ships with drafts greater than 15 feet have always had to wait for higher stages of the tide to cross Knik Arm Shoal, 6 miles southwest of Anchorage. No accidents occur and no queues form at these shoals because pilots have for decades planned their approaches into upper Cook Inlet to avoid any discrete wait for the tide. Pilots of ships nearing Cook Inlet from the Gulf of Alaska (figure D-1) slow their vessels in lower Cook Inlet to meet high tide at the shoals in upper Cook Inlet. The delays associated with tidal access to points beyond the shoals are therefore difficult to assess, since pilots subjectively choose when, how much, and for how long to slow their ships.

The basic objective of the Cook Inlet Navigation Reconnaissance Study was to evaluate the economic feasibility of channel improvements which would prevent some or all of the delays due to the shoals. Previous studies have made broad assumptions regarding the delays suffered by ships in average tidal conditions. These studies did not find any feasible channel alternatives. The tides of Cook Inlet are highly variable on several time scales; therefore, so are shipping delays. Previous studies may have underestimated the effect of this variability on vessel delays and the related cost of shipping. The Cook Inlet Navigation Reconnaissance Study sought to account for tidal variability and to accurately estimate the extra ship time spent to safely navigate the shoals in upper Cook Inlet.

The advice of Port of Anchorage officials, shippers, and pilots was gathered in a series of coordination meetings sponsored by the Corps of Engineers. This advice was applied to formulate a time-and-motion numerical model, which simulates the tides of Cook Inlet, the approach of individual vessels, the decisions of pilots navigating Cook Inlet to Anchorage, and the effect of those decisions on vessel arrival and departure times. Delays departing the Anchorage area also occur. Therefore, it was also necessary to simulate the time for berthing maneuvers, the Port's daily work schedule, and the progress of offloading and loading the vessels. Records of actual arrival and departure times for the calendar year 1991 were provided by the Port of Anchorage. Ship owners and operators provided vessel-specific geometries and operating characteristics, and trip-specific Anchorage-bound departures from the port-of-origin and cargo data. In interviews, Cook Inlet pilots explained what they typically consider when scheduling vessel courses and speeds to navigate up Cook Inlet toward the shoals. The numerical model was formulated to simulate these historical conditions and practical considerations.

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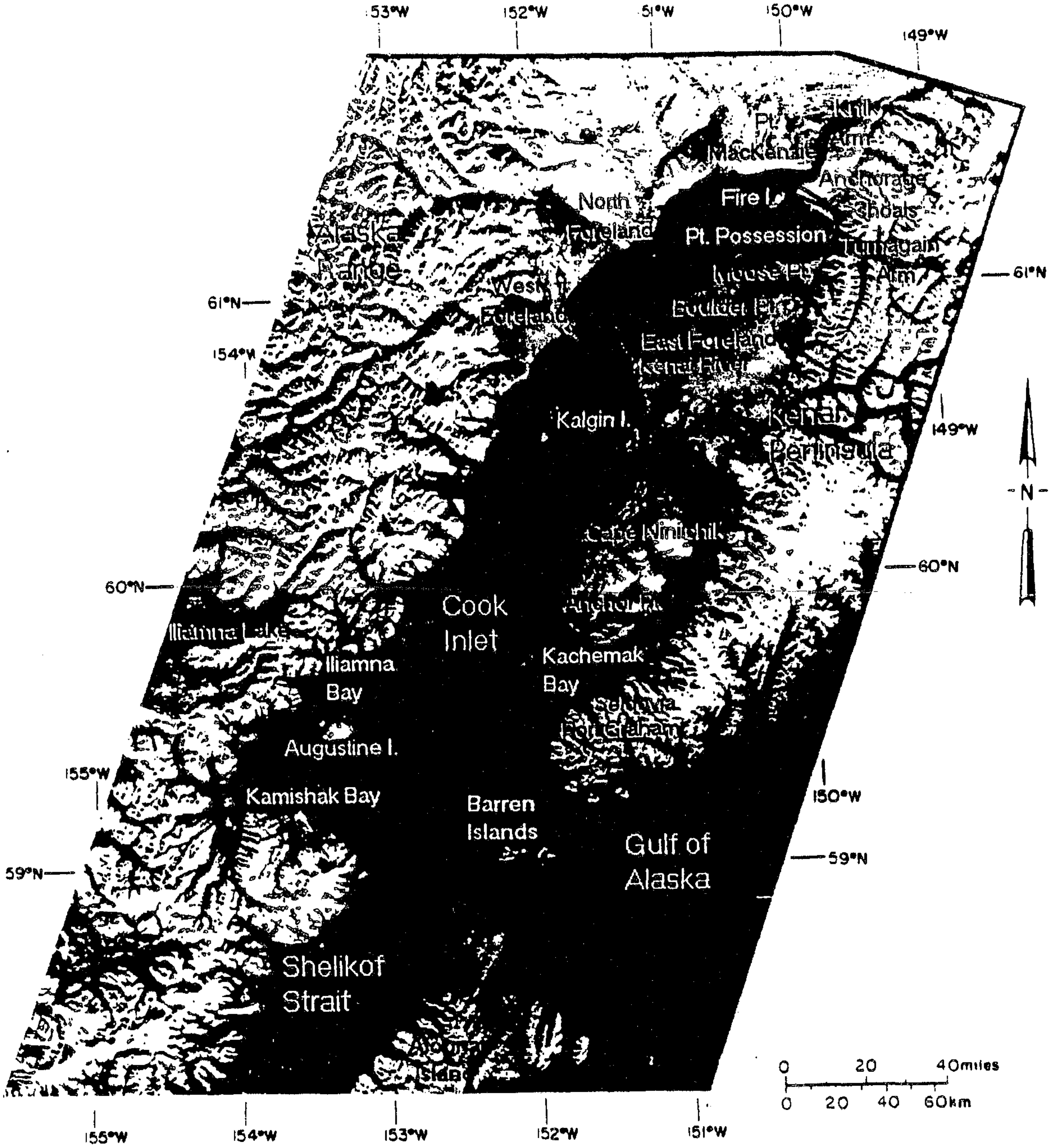

COOK INLET, ALASKA, AND VICINITY

US Army Corps of Engineers
Alaska District

COOK INLET NAVIGATION

D-1

Components of the Program Code

The program is modular in its approach to simulating various aspects of conditions in Cook Inlet and transits of Cook Inlet by individual ships. A main program calls on a set of six principal subroutines to accomplish the numerical simulations, as indicated in figure D-2. The assumptions and program actions of the main program and the subroutines are described in the following paragraphs.

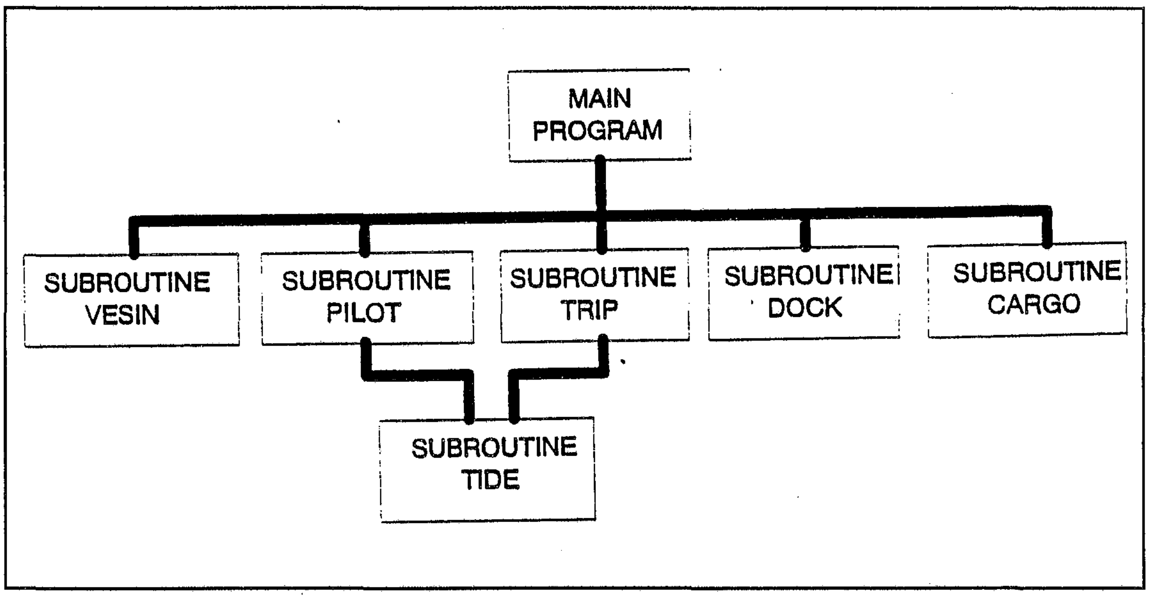

FIGURE D-2.--Schematic of program organization.

The Main Program

The main program specifies the variables used by the program and calls on the subroutines for computations. The only other actions of the main program are to sum the increments of time in each voyage, and to write the output files. Two output files are created for each simulation. An example excerpt from the first output file "transit.txt" is shown in table D-1. This file accumulates values of selected variables which document the progress of each simulated voyage. The first column is the arrival number, which either matches historical records of the Port of Anchorage or includes hypothetical arrivals of vessels which may cross the shoals in the future. Log ships and coal carriers are the two main types of arrivals which were simulated to assess the effect of shoals on possible future traffic in Cook Inlet. The output file "transit.txt" also presents the name of each vessel, its historical (and simulated) time of departure from its port-of-origin in julian days (numbered 0 to 365), its historical time of arrival in Anchorage, its historical time of departure from Anchorage, the distance from Anchorage to the port-of-origin, the cargo amount in trailer equivalent units (TEU) and the rate of cargo transfer in units per hour.

An example excerpt from the second output file, "trandata.txt", is shown in table D-2. This file accumulates key simulation results which correspond to the variables in "transit.txt". The arrival number and ship name are followed by the simulated arrival time in Anchorage, the simulated departure time from Anchorage, the simulated time to discharge cargo, the simulated time spent waiting for the work force to begin offloading and loading, the difference between arrival at full speed and simulated slow speed, and the simulated time waiting for high tide to depart. A summary line is printed at the last of this file including the total number of ship arrivals simulated, the sum of total "slow" times and total "wait" times, the total slow time, the total wait time, the total "work force" time, and the total "cargo" (offloading and loading) time.

TABLE D-1.--*Excerpt from an example "transit.txt" output file*

Trip	Ship	Origin	Arrive	Leave	Distance	TEU	Rate
5	Greatland	5.333	8.375	9.375	1456.000	466.000	65.000
8	Greatland	12.337	15.209	16.143	1456.000	435.000	65.000
10	Westward V	17.108	20.271	20.896	1456.000	382.000	65.000
13	Greatland	19.750	22.820	23.268	1456.000	296.000	65.000
16	Westward V	24.104	27.087	27.747	1456.000	332.000	65.000
18	Greatland	26.271	29.153	29.708	1456.000	272.000	65.000
20	Westward V	31.087	34.283	34.792	1456.000	375.000	65.000
22	Greatland	33.087	36.281	36.774	1456.000	250.000	65.000
24	Westward V	38.076	41.333	41.741	1456.000	364.000	65.000
28	Greatland	40.066	43.142	43.708	1456.000	319.000	65.000
32	Westward V	45.080	48.229	48.750	1456.000	346.000	65.000
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TABLE D-2.--*Excerpt from an example "trandata.txt" output file*

Trip	Ship	Arrive	Leave	Cargo	Tide	Slow	Wait
6	Anchorage	8.513	9.381	12.6	6.7	7.1	1.5
7	Kodiak	13.210	14.305	12.3	14.0	.0	.0
9	Tacoma	15.269	15.671	9.1	.6	2.4	.0
11	Anchorage	20.343	20.757	8.7	.0	3.2	1.3
12	Kodiak	22.413	22.833	7.8	.0	6.9	2.3
17	Tacoma	27.220	27.649	8.6	1.7	.0	.0
19	Anchorage	29.250	29.582	7.0	1.0	1.5	.0
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Total	Delay	Slow	Wait	Workforce	Cargo
101	382.2	324.9	57.3	145.4	934.2

Subroutine VESIN

This subroutine handles the input of vessel and trip variables which identify and specify the controlling parameters of an individual sea voyage. An input file of trip variables is specified interactively by the user, which includes data as illustrated in table D-3. The variables of table D-3 are defined after the table.

TABLE D-3.--*Excerpt from sample input data for individual vessel trips*

TRIP	VID	SHIP	VPORT	VLEFT	VPTIME	VDHERE	VDHIME	VDPRT	VDTIME	VDIST	VFEU	VCTON	VDVTON	VCRGRT
6	1	Anchorage	Tacoma	5	206	8	950	9	1157	1456	1100	383	7544	87
7	1	Kodiak	Tacoma	10	206	13	415	14	426	1456	1072	504	6877	87
9	1	Tacoma	Tacoma	12	112	15	945	16	420	1456	792	263	4428	87
11	1	Anchorage	Tacoma	17	218	20	740	20	2350	1456	754	210	4864	87
12	1	Kodiak	Tacoma	19	12	22	808	22	2255	1456	675	154	4462	87
17	1	Tacoma	Tacoma	24	206	27	735	28	146	1456	746	261	5555	87
19	1	Anchorage	Tacoma	26	142	29	515	30	333	1456	605	162	3969	87
5	2	Greatland	Tacoma	5	800	8	900	9	900	1456	466	851	7242	65
8	2	Greatland	Tacoma	12	805	15	501	16	326	1456	435	686	6868	65
10	2	Westward V	Tacoma	17	235	20	630	20	2130	1456	382	373	6243	65
13	2	Greatland	Tacoma	19	1800	22	1940	23	626	1456	296	330	4793	65
16	2	Westward V	Tacoma	24	230	27	205	27	1756	1456	332	506	5262	65
18	2	Greatland	Tacoma	26	630	29	340	29	1700	1456	272	233	4486	65
20	2	Westward V	Tacoma	31	205	34	647	34	1900	1456	375	522	5967	65
22	2	Greatland	Tacoma	33	205	36	645	36	1835	1456	250	239	4046	65
24	2	Westward V	Tacoma	38	150	41	800	41	1747	1456	364	510	5803	65
28	2	Greatland	Tacoma	40	135	43	325	43	1700	1456	319	229	5303	65
32	2	Westward V	Tacoma	45	155	48	530	48	1800	1456	346	569	5439	65

TRIP	Vessel arrival sequence, from the Port of Anchorage's records.
VID	A ship identification number
SHIP	The registered name of the vessel (or an abbreviation)
VPORT	The port-of-origin from which the vessel departed for Anchorage
VLEFT	Date (julian date) of departure from port-of-origin
VPTIME	Time (24 hour clock) of departure from port-of-origin
VDHERE	Actual arrival (julian) date
VDHIME	Actual arrival time (24 hour clock)
VDPRT	Actual departure (julian) date from Anchorage
VDTIME	Actual departure time (24 hour clock) from Anchorage
VDIST	Distance in nautical miles from Anchorage to port of origin
VFEU	Cargo in trailer equivalent units
VCTON	Cargo in tons loaded at Anchorage
VDVTON	Cargo in tons discharged at Anchorage
VCRGRT	Transfer rate for cargo in units per hour

The subroutine VESIN also reads vessel-specific data from an input file "ship2.txt". Vessel draft and other ship characteristics are specified in "ship2.txt". Table D-4 shows the vessel data applied in the Cook Inlet simulations. The variables of "ship2.txt" are defined below.

SHIPID	Equal to "VID", a matching ship identification number
LINE	Name of the shipping line which operates the vessel
VBEAM	The vessel beam, or maximum width, in feet
VLNGTH	The vessel length, overall, in feet
SBERTH	A code related to berthing requirements = 3: vessel needs flood tide to berth = 4: ship's crew unloads & loads the ship (e.g. for tankers) = 1, 2, 5, ...: not used at present
STL(1)	Equal to VLDRFT: ship's loaded draft in feet
STL(2)	Equal to VDRAFT: ship's light (empty) draft in feet
STL(3)	Equal to VEXTRA: keel clearance required (nominally = 10 ft)
STL(4)	Equal to VNORM: ship's fully loaded cargo capacity
STL(5)	Equal to VSPEED: ship's normal open sea cruising speed
STL(6)	Equal to VTLIM: time step (julian days) for simulating trip
STL(7)	Equal to VWORK: time in % per day longshoremen available
STL(8)	Equal to VTHERE: time needed to berth ship
STL(9)	Equal to VLEAVE: time needed to cast off and get underway
VCOST(1)[1]	Equal to VCRCOST: ~~fuel used at cruise~~ speed
VCOST(2)	Equal to VBERCOST fuel used at port
VCOST(3)	Equal to VMAINCOST: fuel price for main engine
VCOST(4)	Equal to VAUXCOST: fuel price for auxiliary engine
VCOST(5)	Equal to VHP: ship horsepower (main engine)
VCOST(6)	Equal to VCREW: number of crew members
VCOST(7)	Equal to VFIXCOST: daily ship fixed cost
VCOST(8)	Equal to VDWT: ship dead weight tons
VCOST(9)	Equal to VGNT: ship gross net tons

[1] VCOST variables were not applied in simulations for the "Cook Inlet Navigation Reconnaissance Study". Vessel operating costs were instead applied externally to translate estimated ship delays in hours to equivalent transportation costs.

TABLE D-4.--*Ship data applied in Cook Inlet ship transit simulations*

SHIPID	LINE	VBEAM	VLNGTH	SBERTH	STL 1	STL 2	STL 3	STL 4	STL 5	STL 6	STL 7	STL 8	STL 9	VCOST 1	VCOST 2	VCOST 3	VCOST 4	VCOST 5	VCOST 6	VCOST 7	VCOST 8	VCOST 9
1	Sealand	78	710	0	34.33	27.42	10.00	7854	19.5	0.020	0.500	0.030	0.025	41.2	2.5	104.9	203.2	20280	21	42484	20817	20965
2	TOTE	105	790	3	29.00	22.00	10.00	9400	22.0	0.020	0.500	0.030	0.025	105.0	10.5	101.5	101.5	30000	29	37850	15500	17637
3	Chevron	96	651	4	36.67	29.00	10.00	250000	13.5	0.040	1.000	0.030	0.025	50.0	5.0	101.5	0.0	12500	21	35000	39000	16941
4	ABI	83	524	4	33.50	19.00	10.00	22300	13.5	0.040	1.000	0.030	0.025	32.3	2.0	101.5	104.9	11000	0	21020	25402	14921
5	ABI	79	501	4	31.67	18.50	10.00	19400	13.5	0.040	1.000	0.030	0.025	30.0	2.0	101.5	104.9	10000	0	19500	21340	12905
6	Crowley	100	400	4	20.00	3.00	10.00	132500	8.0	0.040	1.000	0.030	0.025	21.5	0.5	104.9	104.9	7200	9	14500	18300	8166
7	Crowley	80	300	4	23.00	3.50	10.00	14188	8.0	0.040	1.000	0.030	0.025	21.5	0.5	104.9	104.9	7200	8	11020	13122	5498
8	Crowley	74	328	4	16.83	4.50	10.00	15140	8.0	0.040	1.000	0.030	0.025	17.2	0.5	104.9	104.9	6000	8	9410	7910	5058
9	Crowley	46	160	4	7.17	2.08	10.00	2539	8.0	0.040	1.000	0.030	0.025	13.1	0.3	104.9	104.9	2000	8	5220	1400	569
10	Crowley	80	398	4	19.00	3.00	10.00	11986	9.0	0.040	1.000	0.030	0.025	21.5	0.5	104.9	104.9	7200	9	11800	12185	10127
11	Del West	78	282	4	14.67	2.61	10.00	6834	10.0	0.040	1.000	0.030	0.025	12.6	0.0	104.9	104.9	3600	0	0	6834	3382
12	Del West	78	282	4	14.67	2.61	10.00	6834	9.0	0.040	1.000	0.030	0.025	9.8	0.0	104.9	104.9	3100	0	0	6834	3365
13	Del West	54	180	4	9.50	2.10	10.00	1900	5.0	0.040	1.000	0.030	0.025	3.9	0.0	104.9	104.9	1080	0	0	1900	1053
14	Almar	106	600	4	36.00	16.00	10.00	280000	13.5	0.040	1.000	0.030	0.025	0.0	0.0	104.9	104.9	9130	14	0	35080	26351
15	Almar	99	597	4	34.50	10.00	10.00	250000	14.0	0.040	1.000	0.030	0.025	0.0	0.0	104.9	104.9	9244	0	0	36998	25733
16	Almar	80	620	5	27.00	27.00	10.00	1	20.0	0.020	0.000	0.030	0.025	0.0	0.0	104.9	104.9	24000	325	0	6353	24474
17	Norweg.	98	645	5	28.83	28.83	10.00	1	19.0	0.020	0.000	0.030	0.025	0.0	0.0	104.9	104.9	16680	0	0	17224	12834
18	Mapco	0	0	4	0.00	0.00	0.00	1	1.0	0.020	1.000	0.030	0.025	0.0	0.0	104.9	104.9	0	0	0	0	0
19	Mapco	84	587	4	34.60	22.00	10.00	200000	15.0	0.040	1.000	0.030	0.025	0.0	0.0	104.9	104.9	14000	22	0	27660	17157
20	all Tugs	0	0	0	16.00	16.00	10.00	1	8.0	0.040	0.000	0.030	0.025	0.0	0.0	104.9	104.9	2000	0	3000	0	0
21	Almar	56	364	5	24.00	24.00	10.00	1	15.0	0.040	0.000	0.030	0.025	0.0	0.0	104.9	104.9	0	80	0	0	6700
22	Almar	0	0	5	0.00	0.00	10.00	1	8.0	0.040	0.000	0.030	0.025	0.0	0.0	104.9	104.9	0	0	0	0	0
23	Almar	78	605	4	34.00	29.00	10.00	180000	15.0	0.040	1.000	0.030	0.025	0.0	0.0	104.9	104.9	15000	20	0	26973	16584
24	Almar	106	600	4	37.00	20.00	10.00	272080	13.5	0.040	1.000	0.030	0.025	0.0	0.0	104.9	104.9	9130	16	0	44999	28256
25	Port Mac	105	745	2	43.30	34.40	10.00	60000	13.0	0.040	0.667	0.030	0.025	43.8	2.5	104.9	104.9	11500	20	13000	60730	32540

Subroutine PILOT

This subroutine simulates the considerations and decisions of a pilot in predicting the time of arrival at Anchorage, making adjustments in vessel speed in lower Cook Inlet so the ship arrives at the shoals with sufficient depth to cross. PILOT also considers the current practice of Totem Ocean Trailer Express (TOTE) roll-on/roll-off vessels (i.e. the M/V *Greatland* and M/V *Westward Venture*) to berth at the Port of Anchorage on a flood tide, so the vessel is maneuvering against the tide during a port-side berthing. A port-side berthing is preferred since the specialized gangway system is designed for the port side of the ship. Decisions regarding passage over the shoals are based on a variable keel clearance requirement. The minimum required depth of water at the shoals, in other words, is the vessel draft plus keel clearance. A keel clearance of 10 feet was applied in simulations for the Cook Inlet Navigation Reconnaissance Study, typical of insurance underwriter requirements for the fleet of commercial vessels now serving Anchorage.

The subroutine PILOT actually becomes active when the simulated position of an approaching ship is 100 nautical miles from the entrance to Cook Inlet. At this point the simulation switches to reduced time steps (of either 1/2 or 1 hour) whose length is associated with the vessel's cruising speed. The subroutine TIDE, which specifies hourly depths and currents at 15 Cook Inlet locations, is called extensively by PILOT to estimate ship arrival time at the shoals. Combinations of reduced vessel speed and duration at reduced speed are simulated in sequence until one combination results in safe passage over the shoals, i.e. the vessel draft plus keel clearance does not exceed the water depth at the shoals at the time of arrival. The trial-and-error process also considers the need for a flood tide berthing, if necessary. A similar process is followed by PILOT when it is called again to plan the ship's departure from the dock.

Subroutine TRIP

Subroutine TRIP accomplishes the actual simulation of the ship's transit of Cook Inlet, computing position versus time for each time step of the journey. The plan developed by PILOT is applied to guide the ship up Cook Inlet toward Anchorage. The trip up Cook Inlet consists of a minimum 15 segments, corresponding to 15 tables of tide heights and currents for segments of Cook Inlet illustrated in figure D-1. The subroutine TIDE is called repeatedly to determine the tidal currents that either oppose or follow a ship in its journey up Cook Inlet. The ship speed over ground is determined by adding the tidal current to the ship's speed through the water. Most simulated journeys involve more than 15 segments, since the specified time step of 1/2 to 1 hour is rarely adequate to allow crossing of all tide related segments of Cook Inlet in one time step. The journey down the inlet is not simulated through segments beyond the crossing of Fire Island shoal in applications for the Cook Inlet Navigation Reconnaissance Study.

A graphics file is created by TRIP for an optional plot of ship position and ship speed versus time. An example of one ship's simulated transit is presented in figure D-3. This

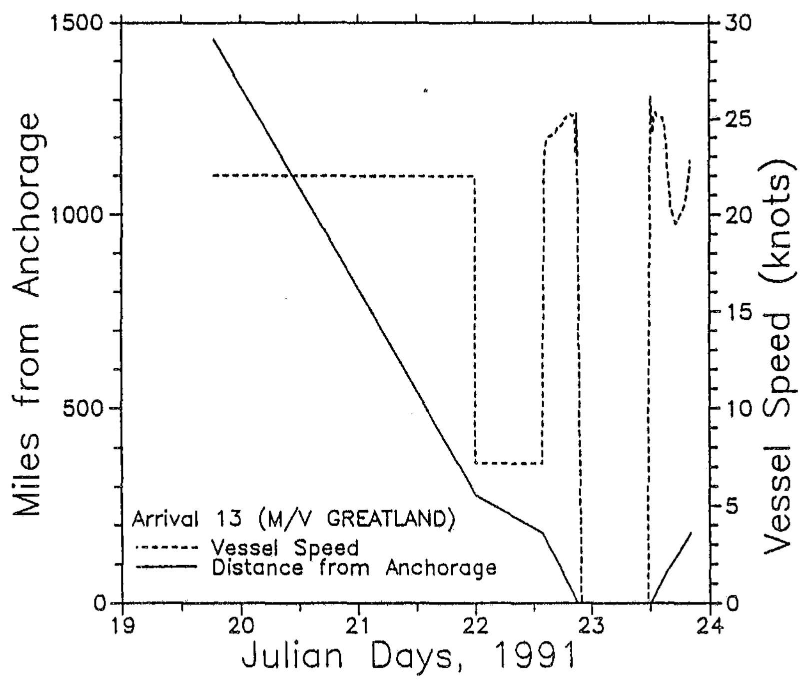

FIGURE D-3.--Sample plot of ship position and speed versus time during a simulated Cook Inlet transit.

figure illustrates the approach of the Sealand vessel M/V *Tacoma* and the simulated pilot decision to slow down in lower Cook Inlet in order to reach Fire Island Shoal and Knik Arm Shoal at high water. The time of zero distance and motion is the time that the ship is at the dock, either waiting for the work day to begin, being unloaded and loaded, or waiting for a high enough tide to depart and cross the shoals outbound. Knik Arm Shoal and Fire Island Shoal are only 6 nautical miles apart, so containerships cruising at 20 knots (kts, nautical miles per hour) cross both shoals in about 20 minutes. Knik Arm Shoal has a controlling depth of -25 ft MLLW and Fire Island Shoal has a controlling depth of -48 ft MLLW over its northern flank. Effectively pilots need only plan for sufficient high water at Knik Arm Shoal and navigability of Fire Island Shoal is automatically assured.

Subroutine TIDE

The subroutine TIDE reads data from any one of a series of 15 tables of julian date (in fractions at hourly intervals), depth (mean chart depth + predicted tide height above MLLW), and current (positive for flood, negative for ebb). Chart depth is the bottom elevation with respect to MLLW. The subroutine TIDE iterates between table values to estimate the depth and current to within 15 minutes. The tide table applied in simulations for the Cook Inlet Navigation Reconnaissance Study are based on predicted tides for the calendar year 1991.

Creation of Tide Tables used by the Subroutine TIDE: The NOAA program "NTP4" was applied to create tabular time series of tide heights and current at 15 locations along Cook Inlet. This program is used by NOAA to prepare the Tide Tables publications published by that agency. The program in its unmodified form prepares tables of the time and height (with respect to MLLW) of high tides and low tides at specific "master stations" along the coast. Two master stations apply to the tides of Cook Inlet: Seldovia, on Kachemak Bay in lower Cook Inlet, and Anchorage, in Knik Arm. The Tide Tables separately print corrections to these times and heights for subordinate stations at coastal locations between master stations. A special version of NTP4 is required for Anchorage because of its exceptionally complex tides. NTP4 predicts tides on the basis of a set of harmonic constituents, or frequency factors which apply at a given geographical location. These constituents are derived by NOAA from tidal records at the master station locations which exceed 19 years in length. The need for such a long record relates to the periods of various astronomical cycles which change the gravitational pull of the sun-earth-moon system. The standard version of NTP4 applies 37 tidal constituents to simulate significant effects on the sea surface of these astronomical cycles. The Anchorage version of NTP4 applies 124 tidal constituents to more accurately simulate the complex tides that occur in Knik Arm.

Both versions of NTP4 were first modified to tabulate the time of tide heights in julian days, rather than the standard month and day format. Another modification allowed automatic incorporation of time and height corrections for any specific subordinate station. The subordinate station corrections applied in the Cook Inlet Navigation Reconnaissance Study, corresponding to segments of Cook Inlet as indicated by figure D-1, are listed in table D-5.

The standard version and Anchorage version of NTP4 have the option of tabulating all hourly tide heights, rather than just the times and heights of high water and low water. This option was not used, even though hourly predictions were necessary for the ship transit simulations. Rather, a smooth half-cycle sinusoidal variation was imposed between each predicted high water and low water, and hourly heights were interpolated along the sinusoidal curve. The exact predicted time and height of high water and low water are retained in the output, whether or not they occur on an even hour.

Zero current was assumed to exist at the time of each high water and low water. Tidal currents were assumed to vary as a function of water surface slope, of depth, and of the roughness of the sea bottom. Stated differently, a balance between friction and inertia was assumed at each point in time. This assumption is not generally valid for tidal flows, but it serves as an expedient way in this application to predict a tidal current for each stage of the tide, given only an average depth and bottom condition at a site. The approach allows adjustment of the friction parameter to "tune" the tidal currents to

TABLE D-5.--*Tidal data applied in the Cook Inlet Navigation Reconnaissance Study*								
Location	Latitude	Mean shipping route depth (ft)	Source of correction	Time Correction (julian days)		Height Correction		Master Station
				High water	Low water	High water	Low water	
Barren Islands	58.9450	360	published	-0.0056	-0.0028	x 0.76	x 0.76	Seldovia
Port Graham	59.4667	240	published	-0.0056	-0.0097	-1.0 ft	+0.0 ft	Seldovia
Anchor Point	59.8000	120	published	+0.0201	+0.0146	+0.4 ft	+0.0 ft	Seldovia
Cape Ninilchik	60.0500	120	published	+0.0285	+00375	+1.2 ft	+0.2 ft	Seldovia
Kalgin Island	60.2833	120	interpolated	+0.0532	+0.0666	+2.0 ft	+0.4 ft	Seldovia
Kenai River mouth	60.5500	120	published	+0.0778	+0.0958	+2.7 ft	+0.5 ft	Seldovia
East Foreland	60.7000	90	published	+0.1090	+0.1236	+3.0 ft	+0.5 ft	Seldovia
Boulder Point	60.8500	90	interpolated	+0.1207	+0.1367	+4.2 ft	+0.5 ft	Seldovia
North Foreland	60.9667	90	published	+0.1359	+0.1537	+5.8 ft	+0.5 ft	Seldovia
Moose Point	61.0833	70	interpolated	+0.1485	+0.1685	+7.0 ft	+0.6 ft	Seldovia
Point Possession	61.1500	70	interpolated	+0.1611	+0.1833	+8.2 ft	+0.6 ft	Seldovia
Fire Island Shoal	61.1833	48	interpolated	-0.0217	-0.0242	x 0.92	x 0.92	Anchorage
Race Point	61.1667	70	published	-0.0174	-0.0194	x 0.94	x 0.94	Anchorage
Knik Arm Shoal	61.2000	25	interpolated	-0.0131	-0.0146	x 0.96	x 0.96	Anchorage
Anchorage	61.2333	90	published	0.0	0.0	0.0	0.0	Anchorage

match representative values published each year by NOAA in Tidal Current Tables. Manning's equation for open-channel flow was applied for this purpose.

$$U = \frac{1.49}{n} d^{2/3} S^{1/2}, \qquad (1)$$

where U = vertically averaged current speed in feet per second
n = Manning's "n" friction factor
d = depth in feet, assuming a wide flow cross-section
S = water surface slope

Comparison of predicted and published current statistics: The tide current algorithm was adjustable by the Manning's "n" friction factor for matching its current predictions with published representative currents in the NOAA Tidal Current Tables. The 1991 tables were consulted for locations along the shipping route in Cook Inlet to Anchorage. Currents are specified by NOAA in terms of "average maximum flood" and "average maximum ebb". The maximum hourly currents predicted by the tidal current algorithm for each phase (flood or ebb) of each tide in the calendar year 1991 were averaged for comparison to tidal current statistics published by NOAA for the nearest location. Manning's "n" was adjusted to create a new tide table for each subordinate station until the predicted average maximum flood current and maximum ebb current (from the hourly currents predicted for 1991) matched as closely as possible to the published values. This method was used for predicting hourly tidal currents at all subordinate stations except the deepest station (360-foot-depth) at the Barren Islands.

Tidal Current Predictions at the Barren Islands: The development of predicted tidal currents based on a quasi-steady balance between inertia, as measured by surface slope, and friction, proved to predict currents close to published values, except at the deeper locations in lower Cook Inlet. The expedient method of adjusting friction appeared not to work for these deep stations where bottom friction has less influence than other factors. An alternative formulation of tidal flows was attempted, based on inviscid plane wave theory. The dispersion relation for shallow water inviscid plane waves at constant depth is:

$$C^2 = \sqrt{C_o^2 + \frac{f^2}{K^2}} \quad , \tag{2}$$

where
C = the phase speed, or speed of a wave crest, = L/T,
T = wave period,
C_o = the phase speed of a shallow water linear wave = (gd),
g = the acceleration of gravity,
f = the Coriolis parameter = $2\Omega\sin\theta$,
Ω = earth's rate of rotation = 7.3×10^{-5} sec^{-1},
θ = latitude (see Table 5),
K = wave number = $2\pi/L$, and
L = wave length (L >> d).

Water particle velocity, i.e. current speed (u), perpendicular to the crest is:

$$u = \frac{|\eta_o|}{d} C\cos(Kx - \sigma t + \phi) \quad , \tag{3}$$

where η_o = amplitude of the wave,
x = distance before crest,
σ = wave frequency = $2\pi/T$, and
ϕ = phase.

Solving for wave length, L,

$$L = 2\pi \sqrt{\frac{gd}{(\frac{2\pi}{T})^2 + f^2}} \quad , \tag{4}$$

which can be applied to solve for C, since g, d, T, and f are known. The maximum current is of concern, so Kx - σt = 0 and cos(Kx - σt) = 1. The maximum current follows high (or low) water by a phase of $\pi/2$ (90°). The 360-foot-depth at the Barren Islands yields an estimate of 2.8 knots for maximum current, while Manning's equation predicted over 4 knots. Adjustment at this depth of friction could not bring currents predicted by Manning's equation into a range close to that measured nearby by NOAA.

The inviscid shallow water wave estimate is more reliable for this deep open location. Adjustment of Manning's "n" served as an expedient method to predict realistic currents at other shallower stations. It should be noted, however, that the earth's rotation has a significant effect on tidal currents in Cook Inlet, as indicated by the fact that the value of f^2/K^2 is of the same order as C_o^2 in the dispersion relation (equation 2). Future simulations of Cook Inlet ship transits could include more accurate non-linear estimates of tidal currents, but this refinement does not appear to have significant consequences to practical conclusions drawn from simulation results.

Table D-6 shows the comparison for the values applied for creating the tide tables applied in the Cook Inlet Navigation Reconnaissance Study. Values of Manning's "n" all fall within the range of values in general use for irregular sandy bottoms, without much plant growth. Values published by NOAA are intended as representative values for reference by mariners navigating the region and often are the product of only short-term measurements. The specific location, depth, and time of year of short-term measurements could affect the published current values by a knot or more. Likewise, the specific location could affect the difference between the flood and ebb current speeds. Furthermore, the maximum currents reported by NOAA may also be a spatial maximum, rather than a vertical average current, as predicted by Manning's equation. The assumption of sinusoidal variation of water surface elevation between predicted high and low waters and slope-driven currents in the predictions resulted in consistently stronger long term average flood currents. Higher-order variations in real ebb tides tend to make real ebb current flows stronger.

TABLE D-6.--*Comparison of predicted and NOAA published current statistics*						
Tide Station	Assumed values		Average maximum currents (knots)			
			Predicted		Published	
	Depth (ft)	Manning's "n"	Flood	Ebb	Flood	Ebb
Barren Islands	360	inviscid estimate	1.2	-1.2	1.6	0.9
Port Graham	240	0.047	2.4	-2.5	-	-
Anchor Point	120	0.037	2.4	-2.5	2.4	-2.5
Cape Ninilchik	120	0.032	3.0	-2.9	2.6	-3.5
Kalgin Island	120	0.033	3.0	-2.8	2.7	-3.3
Kenai River	120	0.029	3.5	-3.3	3.1	-3.6
East Foreland	120	0.028	3.4	-3.2	-	-
Boulder Point	90	0.025	3.8	-3.6	3.4	-4.3
North Foreland	90	0.028	3.5	-3.3	3.4	-3.4
Moose Point	70	0.027	3.5	-3.3	-	-
Point Possession	70	0.026	3.7	-3.5	3.6	-3.8
Fire Island Shoal	48	0.025	3.5	-3.2	-	-
Race Point	70	0.026	3.8	-3.6	-	-
Knik Arm Shoal	25	0.024	3.1	-2.9	2.9	-2.3
Anchorage	90	0.028	4.1	-3.7	3.9	-4.0

Subroutine DOCK

This subroutine provides the simulation of berthing and cast-off maneuvers, with a view toward the particular requirements of each ship. Subroutine DOCK also simulates any wait for the dockside workforce to arrive, either to assist with berthing or to unload, by checking the simulated time of arrival and the time berthing maneuvers are complete with the scheduled start of the workday for longshoremen. The requirements for longshoreman service is also considered for each ship, since some ships, e. g. some liquid bulk carriers, are unloaded by their own crew and require no longshoremen. Time spent waiting for the workforce at the dock is stored in a variable "DTLOST".

Subroutine CARGO

Subroutine cargo deals with the offloading and loading the cargo of each ship, as specified in the trip data file, according to its specified individual requirements at the rate specified in the ship data file. This subroutine also keeps track of the daily work schedule at the dock and accounts for cases when cargo is not fully unloaded or loaded in a single work day. This subroutine, on computing the time when a vessel is loaded and ready to leave, starts the clock on tidal delays waiting for high water at the shoals. Subroutines PILOT and TRIP are called in sequence by the main program, for the departure leg when subroutine DOCK has completed its computations.

Results

Verification

The historical 1991 arrival and departure log of the Port of Anchorage was applied to both develop the model and to verify simulated arrival and departure times. The data from the Port of Anchorage log was expanded to include departure dates and times from the ports of origin and detailed characteristics of the ships and cargoes which arrived at Anchorage in 1991. The actual dates and times of departure from the port of origin are input variables for simulated arrivals, as are ship and cargo characteristics. Predicted 1991 Cook Inlet tide heights and currents were tabulated for use in the simulations as discussed previously. These input data result in simulated arrivals at and departures from the Port of Anchorage, which can be compared to the historical arrivals and departures.

Arrivals of loaded containerships provide a thorough test of the model's ability to simulate pilot decisions regarding high tide passage over the shoals. Sea-Land had 101 containership arrivals at the Port of Anchorage in 1991. TOTE had 98 containership arrivals. Differences between predicted and actual arrivals and predicted and actual departures were usually within an hour or two. A less accurate model would miss by one or more high tides, i. e. by 12 hours or more. The human pilot of a real 1991 voyage up Cook Inlet may have chosen to slow the ship by 4 knots for 10 hours, while the model chose to slow the ship by 8 knots for 4 hours. Both the human pilot of the real voyage and the PILOT subroutine chose a plan which will cause the ship to arrive at the shoal at a particular high tide. The rate and duration for slowing the ship which will cause the ship to arrive at high water has many combinations which will be equally successful. The overall duration of the voyage, from the port of origin to the Port of Anchorage, will be affected the same, no matter which successful combination is used.

Figures D-4 to D-7 are scattergrams of simulated and actual arrivals of the 101 Sea-Land 1991 arrivals at the Port of Anchorage. The departures from perfect agreement are indistinguishable at a one year scale. Figure D-8 looks only at Sea-Land arrivals during the icy month of February 1991 and small departures from perfect agreement, i. e. the 45 degree line, can be distinguished. The statistics of the differences between actual and simulated arrivals and departures are more revealing, as presented in table D-7. The mean error of simulations is only 1/2 hour on arrivals, when the major tidal delay occurs for these containerships loaded with import cargo. Larger errors occur, but the arrival error standard deviation of 5.8 hours indicates most simulated arrivals occurred during the same high tide as the actual arrival. The mean departure error was larger, but still less than 6 hours or 1/2 the time between high tides. This mean and the standard deviation of departure errors of 6.3 hours indicate that most of the 199 departures in the sample occurred on the same high tide. The larger errors on departure probably relate to inaccuracies in simulation of cargo transfer rates, the variability of the work shifts, and decisions to depart at high tide with less than a full load. Pilots and shippers who were briefed on these results (see appendix A) had no comment on the statistical comparison, but concurred that the model's prediction of delay times represented their actual experience.

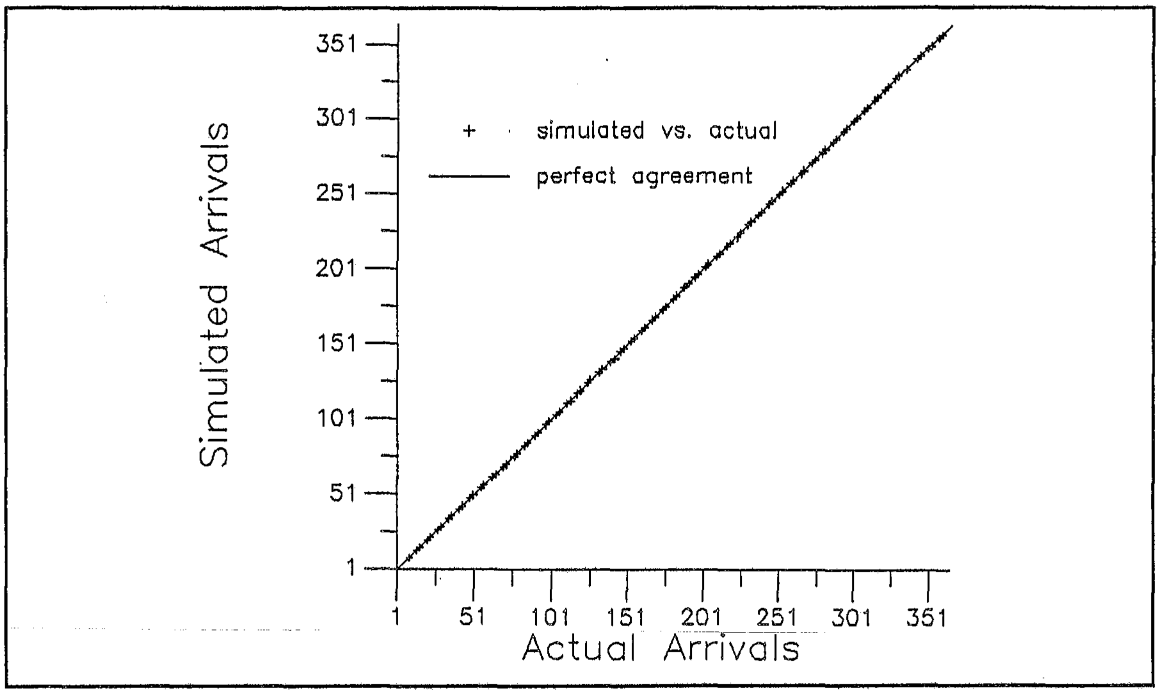

FIGURE D-4.--Simulated versus actual Sea-Land arrivals.

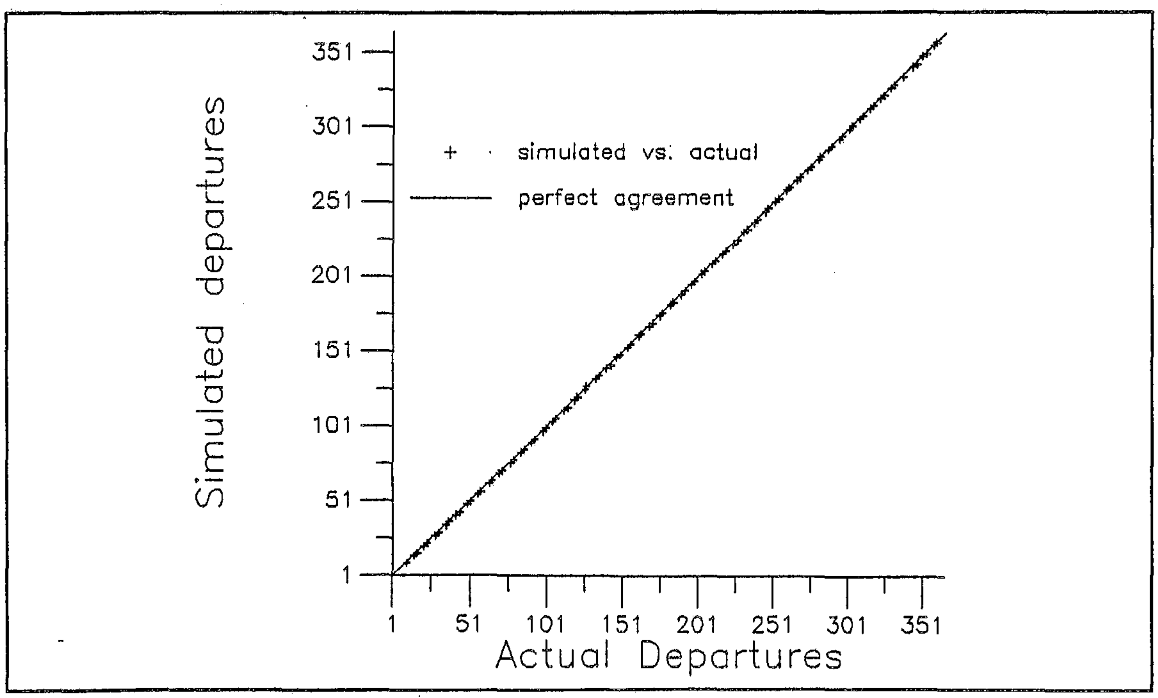

FIGURE D-5.--Simulated versus actual Sea-Land departures.

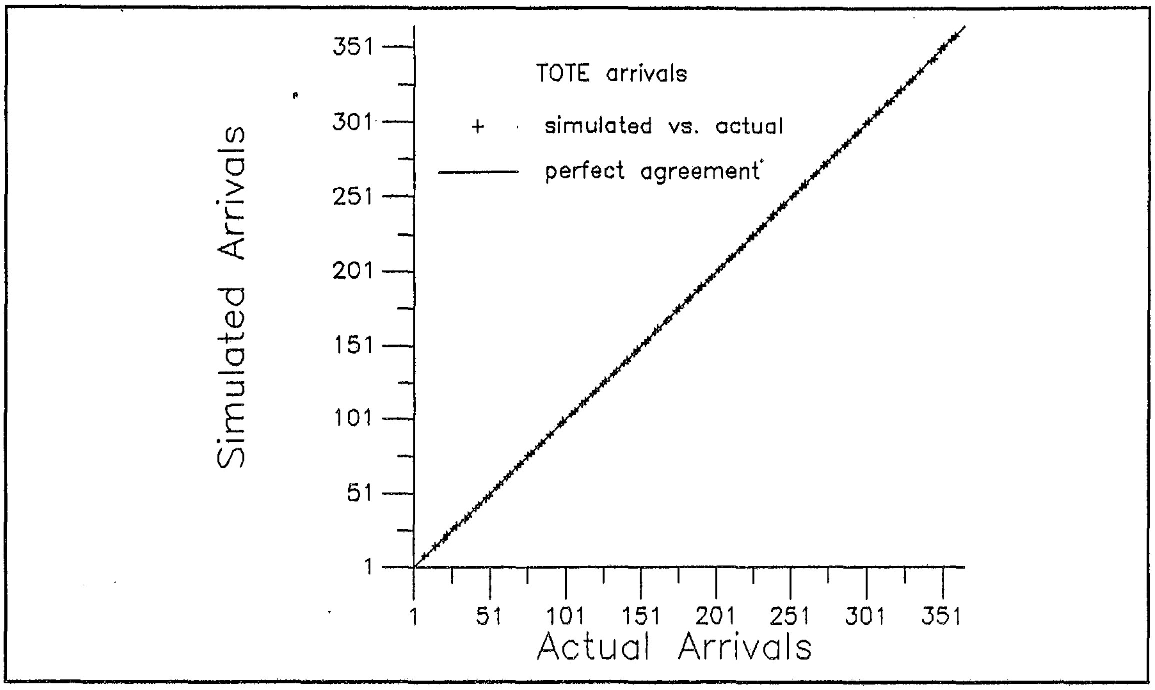

FIGURE D-6.--Simulated versus actual TOTE arrivals.

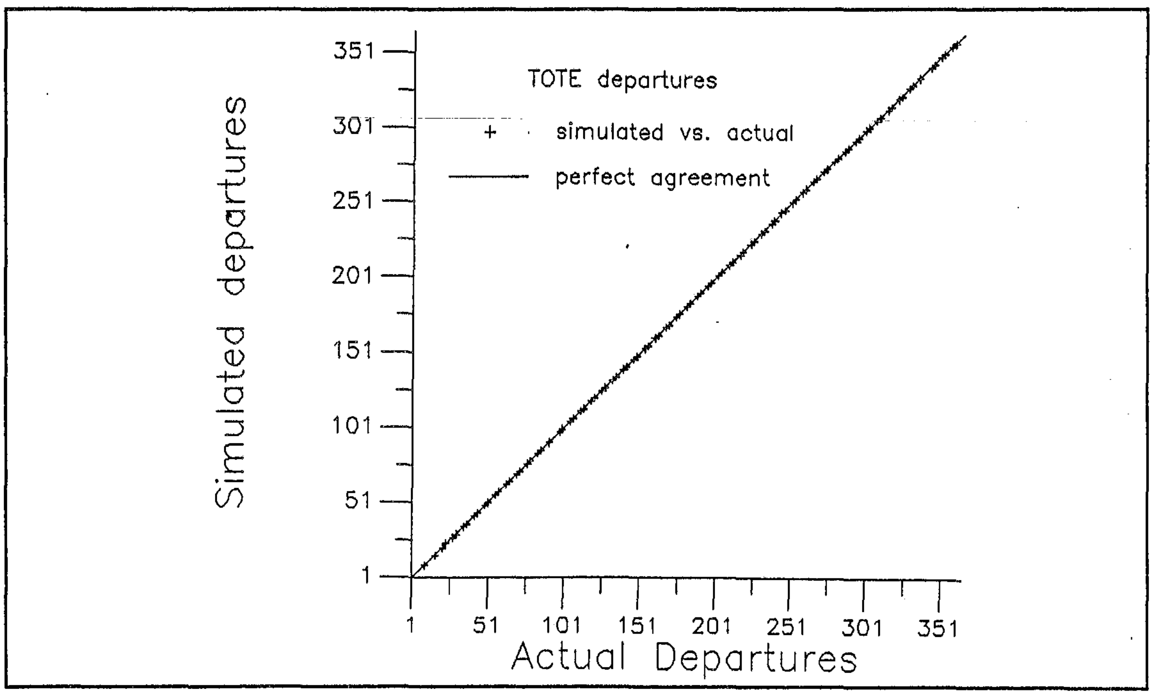

FIGURE D-7.--Simulated versus actual TOTE departures.

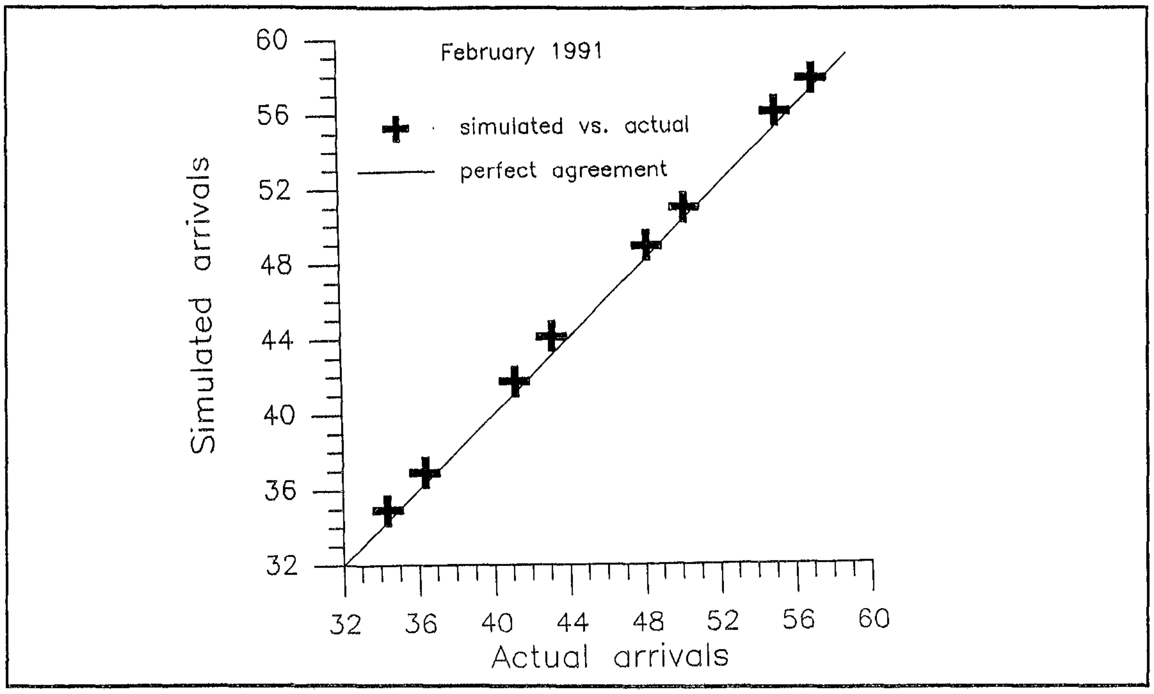

FIGURE D-8.--Simulated versus actual Sea-Land arrivals for February 1991.

TABLE D-7.--*Comparisons of simulated and actual arrivals and departures*

Results compared	Maximum early simulated result	Maximum late simulated result	Mean difference	Standard deviation
Combined Sea-Land and TOTE arrivals	24.4 hrs	32.9 hrs	0.5 hrs	5.8 hrs
Combined Sea-Land and TOTE departures	34.6 hrs	22.9 hrs	5.7 hrs	6.3 hrs

Conclusions

The simulated results predict containership arrivals and departures with adequate accuracy for reconnaissance-level estimation of average delays per vessel and average total delays per year. Containership cargo is projected to continue as the primary traffic into and out of the Port of Anchorage for the foreseeable future. Time savings for this class of vessels are critical to benefit estimates associated with increased tidal access provided by channel excavation. A number of refinements to the simulation program are possible, some using features already programmed but not yet applied. The extensive input data required for the simulation represent a significant challenge to acquire and to verify. Critical input data for the reconnaissance phase simulations were checked on entry. Simulations revealed statistical outliers which were found to have occurred due to data entry errors. Some were corrected, but others were dropped from input data, if correct values were not provided by shippers. The results presented herein represent a good effort to verify all critical input. The statistical comparison shows that simulated 1991 voyages do not exactly match actual voyage arrivals and departures, but the effect of meeting high tide at Knik Arm Shoal was successfully simulated. Pilots concur that predicted delays represent their experience.

Conclusions

The simulated results predict containership arrivals and departures with adequate accuracy for reconnaissance-level estimation of average delays per vessel and average total delays per year. Containership cargo is projected to continue as the primary traffic into and out of the Port of Anchorage for the foreseeable future. Time savings for this class of vessels are critical to benefit estimates associated with increased tidal access provided by channel excavation. A number of refinements to the simulation program are possible, some using features already programmed but not yet applied. The extensive input data required for the simulation represent a significant challenge to acquire and to verify. Critical input data for the reconnaissance phase simulations were checked on entry. Simulations revealed statistical outliers which were found to have occurred due to data entry errors. Some were corrected, but others were dropped from input data, if correct values were not provided by shippers. The results presented herein represent a good effort to verify all critical input. The statistical comparison shows that simulated 1991 voyages do not exactly match actual voyage arrivals and departures, but the effect of meeting high tide at Knik Arm Shoal was successfully simulated. Pilots concur that predicted delays represent their experience.

APPENDIX E

CORRESPONDENCE

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, ALASKA
P.O. BOX 898
ANCHORAGE, ALASKA 99506-0898
SEPTEMBER 11 1991

REPLY TO
ATTENTION OF:

Plan Formulation Section

Honorable Walter A. Hickel
Governor of Alaska
Post Office Box A
Juneau, Alaska 99601-0101

Dear Governor Hickel:

I am pleased to inform you that Congress has appropriated funds to begin a reconnaissance-level study of navigation needs in Cook Inlet. Beginning in October 1991, we will investigate the merits of Federal works such as dredged channels and breakwaters, with emphasis on the needs of deep-draft vessels and related waterborne commerce.

All related previous work by the Corps of Engineers and others will be evaluated and synopsized in our first report. The report will also estimate the potential regional economic benefits of navigation improvements from proposed port developments at Point MacKenzie, the Port of Anchorage, Fire Island, and potential sites in the Kenai Peninsula Borough. Transshipments from interior Alaska and other regions will be considered. The first report is scheduled for completion in November 1992.

If the reconnaissance study finds that any navigation improvements in Cook Inlet appear feasible from a Federal perspective, I will recommend more detailed analyses. These extended studies would include thorough field measurements and advanced technical and economic analyses. The present knowledge of Cook Inlet physical characteristics and regional waterborne commerce trends would be significantly improved by these efforts.

The feasibility phase would require 50/50 cost sharing between the Federal Government and local interests. Local interests in this case may include the State of Alaska, the Municipality of Anchorage, the Matanuska-Susitna Borough, the Kenai Peninsula Borough, and the Fairbanks North Star Borough. The field data collection and technical and economic analyses of the feasibility phase would probably require several hundred thousand dollars in contributions by local interests during each of the first two years of work and a lesser amount during the third (final) year. The feasibility study would begin about May 1993 and end about September 1996, should the reconnaissance study recommend continued investigations.

The study manager for Cook Inlet Navigation will be Dr. Orson P. Smith of my Planning Branch. He will be contacting your staff soon regarding the details of the reconnaissance phase. Your cooperation in providing information will be appreciated. Any suggestions you have regarding our investigation of potential deep-draft navigation improvements will be highly valued. Please furnish your initial views to us by October 11, 1991, to assure that we scope the reconnaissance study to meet your needs.

I look forward to working with you in this effort to serve the public in Alaska. Please contact me directly if I can be of further assistance. Detailed information desired by your staff can be obtained by contacting Dr. Smith at (907) 753-2632.

Sincerely,

John W. Pierce
Colonel, Corps of Engineers
District Engineer

Municipality of Anchorage

OFFICE OF THE MAYOR

P.O. BOX 196650
ANCHORAGE, ALASKA 99519-6650
(907) 343-4431

TOM FINK,
MAYOR

SEPTEMBER 26, 1991

Col. John W. Pierce, District Engineer
Department of the Army
U.S. Army Engineer District, Alaska
PO Box 898
Anchorage, Alaska 99506-0898

Dear Col. Pierce:

I appreciate being advised of the Corps of Engineers general investigative reconnaissance level study of navigation needs in Cook Inlet scheduled to begin in October 1991.

Cook Inlet has the potential of being the hub of economic activity in Alaska. It is currently the focal point for navigation planning and development, driven by a renewed emphasis on the export of natural resources that will offset the declining oil driven economy. The work of the Corps of Engineers will continue to be a critical element as plans for this area progress.

Your point of contact for information and municipal coordination for this study is H. "Glen" Glenzer Jr. Port Director, Port of Anchorage. The Port has conducted a variety of studies of upper Cook Inlet and Knik Arm in cooperation with the Coast Guard, NOAA and other concerned agencies both federal and state. These studies and other information will be available upon your request. I have asked Mr. Glenzer to meet with your staff to insure that Municipality of Anchorage needs are addressed as the scope of the reconnaissance study is determined. He will be contacting your representative shortly.

Again, I appreciate being officially informed of this Corps of Engineers study. If I can be of any further assistance please contact me. Mr. Glenzer can be contacted at the Port of Anchorage 272-1531 or by fax at 277-5636.

Sincerely,

Tom Fink

Tom Fink

cc: G. Glenzer

NOVEMBER 26 1991

Plan Formulation Section

COPY

Rear Admiral J. Austin Yeager
National Oceanic and Atmospheric
Administration (NOAA)
Director, Coast and Geodetic Survey
National Ocean Service
Rockville, Maryland 20852

Dear Admiral Yeager:

The Alaska District is conducting a congressionally authorized regional feasibility study of navigation improvements in Cook Inlet. I am requesting your assistance with field data collection for that study. Recent conversations and a meeting on October 17, 1991, between Lieutenant Commander John Wilder of NOAA and Dr. Orson Smith of my staff, have revealed that NOAA may be able to furnish support for Corps of Engineers' measurements in conjunction with summer 1992 hydrographic operations.

The goal of the Corps' measurements will be to quantify channel stability parameters for both natural and proposed dredged channels along the approaches to Fire Island, Anchorage, and Point MacKenzie. These measurements will be useful for planning future NOAA hydrographic operations and chart publications. Our objectives are complementary, but the measurements we propose would not be possible within our budget without ship support from NOAA.

We need a platform, dynamic positioning (vertical and horizontal), and accommodations for Corps personnel during the following operations:

a. Transects at mid-flood and mid-ebb from (1) Cairn Point to Point MacKenzie north (see enclosed chart excerpt); (2) Point Woronzof to Point MacKenzie south; (3) Point Campbell northwest to mean lower low water (MLLW); (4) Point Campbell to North Point; (5) Race Point northwest to MLLW; and (6) West Point northwest to MLLW.

b. Stationary acoustic measurements throughout a semidiurnal tide cycle (for example, low water to low water) at two mid-inlet stations, one across from Cairn Point and the other across from Race Point, as indicated on the enclosed chart excerpt.

c. Water property profiles (CTD) and water sample profiles at 3 to 4 points along these transects, as indicated on the chart.

d. Bottom grab samples at CTD stations and at other selected points on shoals, as indicated on the chart. Subsamples from other grabs made by NOAA anywhere else in the project area will also be welcome.

Transects will involve tracking two acoustical devices in outboard towed bodies while they measure vertical profiles of echo amplitude. Recent Corps research has shown that echo amplitude is analogous to suspended sediment concentration. The first device, to be operated by Corps personnel, is an acoustic Doppler current profiler. This instrument also measures vertical profiles of current velocity. The second device is a dual-frequency acoustic concentration profiler which will tentatively be provided by Dr. John Proni of NOAA/Atlantic Oceanographic and Meteorological Laboratory (AOML). Both of these devices will be operated during the two stationary measurements. The enclosed report describes analyses to be performed with the measurements. All data collected and subsequent analyses will be made available to NOAA.

Water sample and CTD profiles will be made in a conventional manner from a drifting platform with NOAA equipment, if it is available. Otherwise, the Corps will provide an internally recording CTD sensor package and Niskin-type sample bottles tripped by mechanical messenger. A cable, winch, and outboard block will be necessary for either alternative.

These measurements will be taken by four Corps and two NOAA/AOML specialists. Four of these specialists will need accommodations and support only during the acoustic measurements.

The Alaska District specialist responsible for coordination of these proposed measurements is Dr. Smith of my Planning Branch. Dr. Smith is a physical oceanographer with a great deal of experience in measurements of the type proposed.

Please contact me directly if I can be of further assistance. Detailed technical information can be obtained by contacting Dr. Smith at (907) 753-2632.

Sincerely,

John W. Pierce
Colonel, Corps of Engineers
District Engineer

Enclosures

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Coast and Geodetic Survey
Rockville, Maryland 20852

DEC 19 1991

Colonel John W. Pierce, USA
District Engineer
U.S. Army Engineer District, Alaska
P.O. Box 898
Anchorage, Alaska 99506-0898

Dear Colonel Pierce:

Thank you for your letter requesting assistance from the NOAA Ship RAINIER during the Upper Cook Inlet navigability study. Your request will be passed to the RAINIER through NOAA's Pacific Marine Center (PMC) in Seattle, Washington, with my recommendation that RAINIER assist your operations as much as possible without causing a delay in the ship's authorized schedule. I believe that the ship will be able to accomplish most if not all of the measurements you have requested.

Representatives from PMC will contact Dr. Orson Smith in the near future to coordinate plans and requirements for meeting the desired goals. Lieutenant Commander John D. Wilder, NOAA, Chief, Operations Section, Hydrographic Surveys Branch, will continue to work with Dr. Smith and PMC on the requirements of your request. Commander Wilder's telephone number is 301-443-8752.

Sincerely,

J. Austin Yeager

J. Austin Yeager
Rear Admiral, NOAA
Director
Coast and Geodetic Survey

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of NOAA Corps Operations
Pacific Marine Center
1801 Fairview Avenue East
Seattle, Washington 98102-3767

January 9, 1992

Dr. Orson Smith
U.S. Army Engineer District, Alaska
P.O. Box 898
Anchorage, Alaska 99506-0898

Dear Dr. Smith:

The Pacific Marine Center has approved the Alaska Corps of Engineers (COE) request for support from NOAA Ship RAINIER to acquire CTD's, bottom samples, and Acoustic Doppler Current Profiler (ADCP) measurements during the ship's Northern Cook Inlet project scheduled for June - August 1992. The request has been forwarded to Captain Thomas W. Richards, Commanding Officer, NOAA Ship RAINIER. RAINIER will assist COE as much as possible without causing a delay in the ship's authorized schedule.

Coordination of plans and requirements necessary to meet COE goals can be arranged through Captain Richards at 206-553-4794 (FTS 399-4794). The point of contact at the Pacific Marine Center is Lieutenant David A. Cole, Hydrographic Project Leader at 206-553-4548 (FTS 399-4548). Both Captain Richards and Lieutenant Cole will be in touch with you in the near future to expedite planning arrangements.

Sincerely,

R. L. Speer
Rear Admiral, NOAA
Director, Pacific Marine Center

cc: PMCx1
PMCx4
PMC1
PMC2
PMC3

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of NOAA Corps Operations
Pacific Marine Center
1801 Fairview Avenue East
Seattle, Washington 98102-3767

January 9, 1992

Dr. Orson Smith
U.S. Army Engineer District, Alaska
P.O. Box 898
Anchorage, Alaska 99506-0898

Dear Dr. Smith:

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Coordination of plans and requirements necessary to meet COE goals can be arranged through Captain Richards at 206-553-4794 (FTS 399-4794). The point of contact at the Pacific Marine Center is Lieutenant David A. Cole, Hydrographic Project Leader at 206-553-4548 (FTS 399-4548). Both Captain Richards and Lieutenant Cole will be in touch with you in the near future to expedite planning arrangements.

Sincerely,

R. L. Speer
Rear Admiral, NOAA
Director, Pacific Marine Center

cc: PMCx1
PMCx4
PMC1
PMC2
PMC3

TOTEM OCEAN TRAILER EXPRESS, INC

INTER-OFFICE CORRESPONDENCE

DR SMITH
FOR YOUR INFORMATION
THANKS TED

TO T. DeBoer DATE November 2, 1992

FROM R. Magee

SUBJECT PROPOSED ANCHORAGE CHANNEL DREDGING

With regards to the proposal to establish a 35 M.L.W. controlling depth channel at Anchorage, our position (based upon discussions with several of our pilots and captains) is as follows:

1) In order to warrant that this channel will mean that Anchorage is essentially an open port (not shoal/tidal controlled), it must be 1000 feet wide, properly marked and properly maintained. This is due to the unique combination of expected tidal current, ice, wind and visibility conditions. It is based upon more than 32 ship-years of experience with our hulls and more than 100 man-years experience of our senior people with Upper Cook Inlet.

2) Any improvement in the shoal depth and channel width will help. However, the more severe the tidal, weather, visibility and channel marker/range condition, the greater the tendency will be to make the approach using much more conservative tidal depth criteria than an un-timed approach.

For example, under many conditions the controlling depth would be judged by the Captain to be the shallowest depth anywhere within a 1000 foot hypothetical channel along the approach course track. Remember, our policy is to pass over the hypothetical shallowest spot with a minimum of eight feet of water to be predicted to be under the hull.

This is to account for any combination of unknown shoaling condition, inaccuracy of draft calculation and squatting. This has proven with experience to be a good policy.

The implication of the above position is that as the projected channel width is reduced, the open port concept would be reduced almost linearly.

Summary - Any improvement is most welcome. If the goal is an open port, then a maintained and well-marked channel of 1000 feet is necessary. Anything less than 1000 feet will be taken into account when making the approach and factored into the crossing accordingly.

Bob Magee

RPM/mm

cc: E. Trout
J. Keck
All Captains
All Pilots

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, ALASKA
P.O. BOX 898
ANCHORAGE, ALASKA 99506-0898

REPLY TO
ATTENTION OF:

NOVEMBER 12 1992

Project Formulation Section

Mr. Ted De Boer, Manager
Totem Ocean Trailer Express (TOTE)
2511 Tidewater Road
Anchorage, Alaska 99501

Dear Mr. De Boer:

The Corps of Engineers has, as you know, been engaged since November 1991 in a congressionally authorized feasibility study for deep-draft navigation improvements in upper Cook Inlet. We are considering the prospect of an excavated channel 1,000 feet wide across Knik Arm Shoal, to a depth of 35 feet at MLLW or deeper. Federal participation in such a project requires that the long-term costs of maintaining the channel be offset by an equal or greater savings in transportation costs. Your company provides a significant amount of the maritime transportation services in Alaska; therefore, the effect of the proposed channel on your Alaska operations is of critical importance in our economic analysis.

The following questions correspond to key assumptions in our projection of transportation savings achieved by channel excavation. Please answer these questions as factually as possible. We would appreciate a written response by November 25, 1992.

1. Would a Knik Arm Shoal channel excavated to -35 ft MLLW or deeper cause you to consider changing your schedule of services to Anchorage?

2. Would a Knik Arm Shoal channel excavated to -35 ft MLLW or deeper cause you to consider serving additional (or fewer) ports in Alaska?

3. Would a Knik Arm Shoal channel excavated to -35 ft MLLW or deeper cause you to consider carrying more cargo per vessel trip to Anchorage?

4. Would a Knik Arm Shoal channel excavated to -35 ft MLLW or deeper cause you to consider using different vessels in your service to Alaska?

5. How would the increased accessibility to Anchorage provided by the channel affect your operations with regard to the number of containers stored in Anchorage and Seattle?

6. Is the number of vessels you use in your service to Anchorage likely to change in the next 20 years? In the next 50 years?

7. Approximately when is your present fleet serving Anchorage likely to be retired and replaced with new vessels?

8. How much ($ or percent) would a Knik Arm Shoal channel excavated to -35 ft MLLW affect

a. Your vessel insurance costs?

b. Your maintenance and repair costs?

c. Your crew labor (wages and benefits) costs?

d. Your administrative costs?

e. Your fuel costs?

f. Your costs for other expendables?

Please add comments and facts regarding other aspects of the effect of a Knik Arm Shoal channel excavation on your operations in Alaska. You may call our economist, Mr. Richard Geiger, at 753-2619, or our principal investigator for Cook Inlet navigation, Dr. Orson Smith, at 753-2632 for further explanation of our economic needs and concerns. Your cooperation in this matter is earnestly appreciated.

Sincerely,

Claude V. Vining
Chief, Engineering Division

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, ALASKA
P.O. BOX 898
ANCHORAGE, ALASKA 99506-0898

REPLY TO
ATTENTION OF:

NOVEMBER 12 1992

Project Formulation Section

Mr. Jim McKenna, Manager
Sea-Land Freight Service, Inc.
1717 Tidewater Road
Anchorage, Alaska 99501

Dear Mr. McKenna:

The Corps of Engineers has, as you know, been engaged since November 1991 in a congressionally authorized feasibility study for deep-draft navigation improvements in upper Cook Inlet. We are considering the prospect of an excavated channel 1,000 feet wide across Knik Arm Shoal, to a depth of 35 feet at MLLW or deeper. Federal participation in such a project requires that the long-term costs of maintaining the channel be offset by an equal or greater savings in transportation costs. Your company provides a significant amount of the maritime transportation services in Alaska; therefore, the effect of the proposed channel on your Alaska operations is of critical importance in our economic analysis.

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4. Would a Knik Arm Shoal channel excavated to -35 ft MLLW or deeper cause you to consider using different vessels in your service to Alaska?

5. How would the increased accessibility to Anchorage provided by the channel affect your operations with regard to the number of containers stored in Anchorage and Seattle?

6. Is the number of vessels you use in your service to Anchorage likely to change in the next 20 years? In the next 50 years?

7. Approximately when is your present fleet serving Anchorage likely to be retired and replaced with new vessels?

8. How much ($ or percent) would a Knik Arm Shoal channel excavated to -35 ft MLLW affect

a. Your vessel insurance costs?

b. Your maintenance and repair costs?

c. Your crew labor (wages and benefits) costs?

d. Your administrative costs?

e. Your fuel costs?

f. Your costs for other expendables?

Please add comments and facts regarding other aspects of the effect of a Knik Arm Shoal channel excavation on your operations in Alaska. You may call our economist, Mr. Richard Geiger, at 753-2619, or our principal investigator for Cook Inlet navigation, Dr. Orson Smith, at 753-2632 for further explanation of our economic needs and concerns. Your cooperation in this matter is earnestly appreciated.

Sincerely,

Claude V. Vining

Claude V. Vining
Chief, Engineering Division

CW KH-P

TOTEM OCEAN TRAILER EXPRESS, INC.

November 24, 1992

Mr. Claude V. Vining
Chief, Engineering Division
Department of the Army
US Army Engineer District, Alaska
P.O. Box 898
Anchorage, Ak. 99506

Dear Mr. Vining:

In response to your letter of November 11, 1992, asking various questions pertaining to the economics of an excavated channel 1000 ft wide across Knik Arm shoal, to a depth of 35 feet at MLLW or deeper, I offer the following replies.

These costs are difficult to estimate because the interrelationships of the various operations are so complex and tightly linked. The costs of delays tend to multiply just as savings of fuel, longshore overtime, equipment leasing, equipment damage and insurance can pyramid.

For example, a single missed sailing caused by a failure to be able to exploit a short improvement in the local weather or a pier collision or a damaged propeller can triple those that I have estimated. This shallow shoal is a serious problem to our operation that we routinely overcome due to the special skill of our people; therefore we tend to underestimate how difficult and costly it is.

1. Yes. A Knik arm shoal channel excavated to -35 foot MLLW would cause an improved schedule of service to Anchorage. In the period 1990-1992 we have averaged 10 shoal-induced delays per year. This represents 10% of arrivals. Combined with the Gulf of Alaska weather, this gives Anchorage relatively lower quality service than other Pacific Coast ports.

2. Yes. A -35 MLLW channel would improve schedule keeping enough to improve the economics of a potential Anchorage and Aleutian feeder service.

3. Yes. This deeper channel would make carrying more cargo a possibility. Currently we do not avoid carrying any cargo because of draft. However, future new ships would require deeper drafts. As a rule of thumb, each foot increase in draft enables a vessel of our hull design to

carry approximately 1,000 tons of additional cargo (after deduction trailer weight). This is equivalent to about 40 highway trailers. The incremental expense to do so is quite small (i.e. same crew size, only a bit more fuel, insurance, stevedoring, etc.).

4. Absolutely. A deep channel to 35' MLLW would permit a new design of ship, with greater capacity that would have a very positive effect on holding down unit cost.

5. Container storage is a function of either customer turnaround (i.e. the box is a small, short-term warehouse) or overcapacity of inventory in slack season to meet peak season needs or an overall increase in inventory due to larger demand for trailer moves (that is, larger freight volume demand equals larger ships equals more boxes equals more need for storage on terminal).

   The larger channel itself would have no impact on this storage issue except to the extent that:

   a. The larger channel would have the immediate benefit of preventing schedule disruptions that in turn cause trailer inventory disruptions/storage problems as ships are short-loaded to pick up time in port to make up lost time. In these cases short-term leased equipment must be added to our inventory to meet customer demand. It's like a forced increase in a business's working capital requirement without an increase in revenues or profitability.

   b. Increased volumes require larger storage facilities on terminal.

6. It is highly probable that the number of vessels that we operate to Anchorage will increase by 50% within 2 years and by 100% within 20 years not including potential feeder services which could further increase service.

7. Barring a major policy change in the U.S. Build Provisions of the Jones Act, we are likely to operate our existing ships or another 10-15 years before retirement/replacement.

   A D.O.D./MARAD program to build/charter brand new ro/ro ships that would be both commercially viable and militarily useful could also accelerate the above plan and would result in new, deeper draft ships by 1996.

Anchorage-bound ships of this class would pay a cost penalty given the current channel depth.

8. A 35 MLLW depth might be expected to save TOTE the following:

   a. $50,000 per year in vessel and cargo insurance.

   b. $100,000 per year in maintenance and repair costs.

   c. $50,000 per year in crew costs.

   d. $50,000 per year in administrative costs.

   e. $400,000 per year in fuel costs at $20 per barrel fuel prices. Prices have ranged between $9 and $27 in the past two years. Current prices are $15 and vary enormously with no relation to the CPI. In the 1994-1995 time frame, $20 is a reasonable expectation assuming no serious supply problems.

   f. $200,000 per year for all other miscellaneous costs associated with the current level of service disruption caused by the shallow water access to Anchorage.

I have other thoughts related to this issue that in their entirety add up to m ore economic value to Anchorage than just the impact to the two major water carriers as follows:

1. The safety of navigation for tank vessels, cruise ships and Naval vessels. A nuclear aircraft carrier has been isolated inside this shallow shoal in a promotional visit to Anchorage. The "standard" daft for a <u>modern</u> product tanker is 38 feet or more. Remember, no one in their right mind would cross this shoal with less than 5 feet under the hull. The cost of a single catastrophe could be more than a billion dollars.

2. The impact to the various quick turnaround, just in time inventory retail and wholesale establishments in Anchorage/Fairbanks.

3. The impact to the ability of Anchorage to attract deeper draft vessels of all type and nationality for both import and export business. Average containerships draw 34 feet (plus 5 for the shoal). Average bulk oil, coal and product ships draw 40 feet. This business opportunity cannot be exploited.

4. Missed rail connections to Fairbanks cause additional service delays to that inland market. Missed southbound Pacific foreign linehaul connections can add a week to Alaska's fish export transits.

If you have any questions please call me at 265-7211.

Sincerely,

TOTEM OCEAN TRAILER EXPRESS, INC.

Ted DeBoer
Operations Manager

Sea-Land

CW

Sea-Land Service, Inc.
2550 Denali
Suite 1604
Anchorage, Alaska 99503
907 274 2671

December 2, 1992

Mr. Claude V. Vining
DEPARTMENT OF THE ARMY
Chief Engineering Division
P. O. Box 898
Anchorage, Alaska 99506-0898

Dear Mr. Vining:

In response to your recent request for additional information pertaining to proposed deep-draft navigation improvements in upper Cook Inlet, please be advised of the following:

1. A Knik Arm shoal channel excavated to 35 feet MLLW or deeper would not be cause for Sea-Land to change our present schedule of services to Anchorage, however, it would certainly improve our vessel schedule integrity and thus our reliability to our customer base.

2. A Knik Arm shoal channel excavated to 35 feet MLLW or deeper would most definitely enhance our flexibility and could ultimately lead to the servicing of additional ports in Alaska and/or servicing existing ports on a more frequent basis.

3. The excavation of the channel will not result in the carriage of additional cargo per vessel trip to Anchorage.

4. Excavation of the channel will not have an impact on the vessels utilized in the Alaska Service.

5. Increased accessibility will reduce the number of containers currently required to support the Alaska Service as well as storage needs in both Anchorage and Seattle.

6. I do not foresee a change in the number of line haul vessels currently deployed in Sea-Land's Service to Anchorage.

7. It is expected that the fleet which is presently serving Anchorage will remain doing so for a minimum of 20 years.

Sea-Land

8. As a result of the Knik Arm shoal channel being excavated to 35 feet MLLW, it is anticipated that the following savings/earnings would be realized:

   a. Vessel Insurance Expense - N/A
   b. Maintenance and Repair Expense - $101,000/year
   c. Stevedore Labor Expense - $273,000/year
   d. Administrative Expense - $29,000/year
   e. Fuel Expense - $234,000/year
   f. Miscellaneous (Capital/Lost Revenue Opportunities) - $4,200,000

As evidenced from the above, there is a tremendous amount of capital, expense and lost revenue opportunities which can be directly associated with the Knik Arm shoal channel situation as it exists today. Any effort(s) to resolve this ongoing impediment would be appreciated/supported.

If I can be of any further assistance, please do not hesitate to contact me.

Sincerely,

SEA-LAND SERVICE, INC.

James C. McKenna
General Manager, Alaska

JCM:cm

PORT OF
ANCHORAGE

February 8, 1993

John W. Pierce
Colonel, Corps of Engineers
Commander and District Engineer
Post Office Box 898
Anchorage, Alaska 99506-0898

Subject: Cook Inlet Navigation Reconnaissance Study

Dear Col. Pierce:

John

We appreciate the effort and interest shown by the Corps of Engineers to accomplish this important study and to keep us informed of your progress.

Since the Port of Anchorage handles in excess of 80% of Alaska's cargo, including a substantial amount of U.S. Department of Defense cargo, we believe that federal, state and local interests will benefit from improving the sea channel access to this Port.

From this Port's standpoint, we sincerely support the study's preliminary findings which, as we understand, show that the benefits of improving the navigation channel in the area of the Knik Arm Shoal substantially exceed the cost. As you are no doubt aware, the Reconnaissance Study was briefed to Mayor Fink last Thursday. I believe his questions were indicative of his interest in this subject. We look forward to receipt and confirmation of the final study.

The preliminary study has indicated that there may be various approaches used to proceed with the next phase of this project. We would encourage you to provide the Port with the Corps of Engineers' recommended approach to accomplishing and funding this

2000 Anchorage Port Road Anchorage, Alaska 99501 Telephone: (907) 272-1531

next phase, as soon as practicable, so that we can effectively assist with and organize the effort to obtain matching funds.

John, please contact me personally if I can answer any questions or provide you with further information or assistance.

Sincerely,

Don Dietz
Port Director

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